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-:- NORTHWEST SCIENCE -:-

A journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

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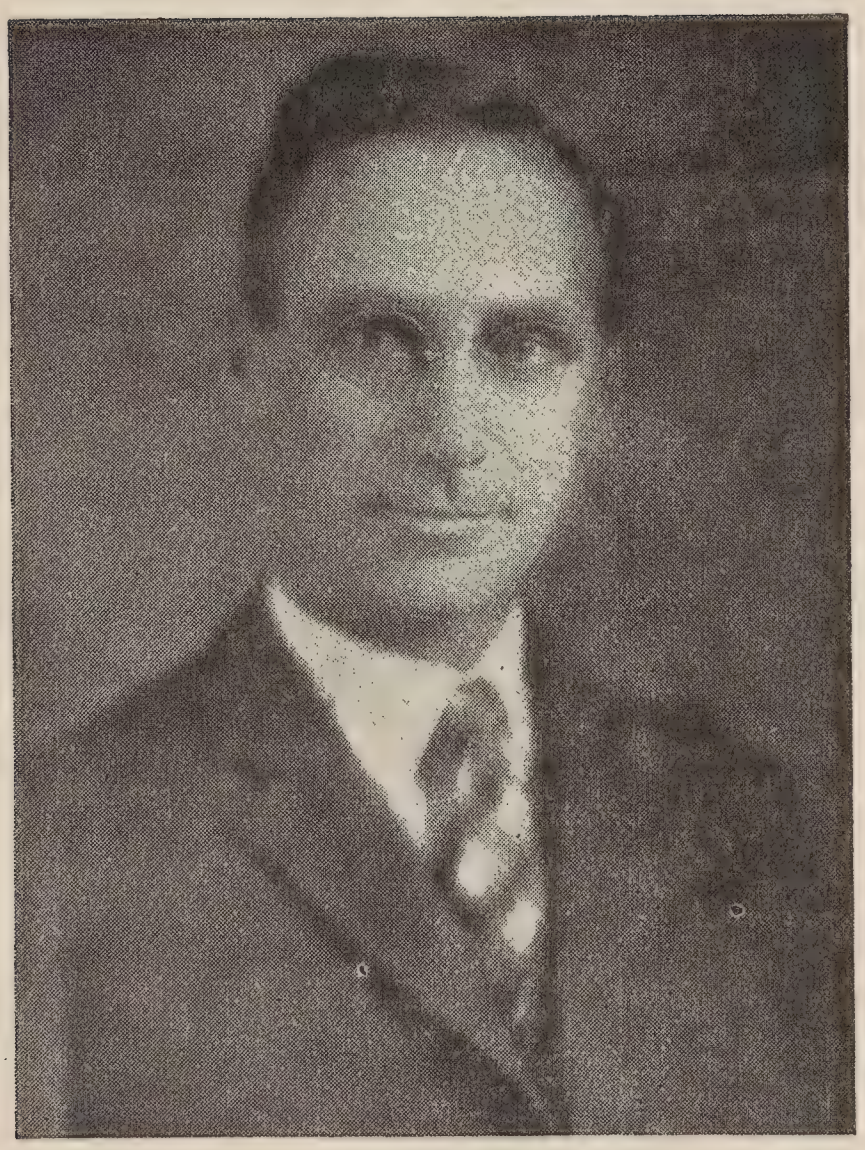
MAR 3 1937



CLARE CHRISMAN TODD
PRESIDENT OF N. W. S. A. FOR 1937

Again our Association has selected a native of the Northwest for President. Dr. Todd was born at McMinnville, Oregon. His collegiate training was received at Washington State College, with B. S. degree in 1906. He was fellow in the Department of Chemistry of Chicago University, receiving the degree of Phd. in 1914. At his Alma Mater he has successively held positions of Instructor, Assistant Professor, Associate Professor, Professor of Chemistry, Professor of Organic Chemistry, and Dean of the College of Arts and Sciences.

A charter member of the organization, Dr. Todd has been a faithful attendant and a participant in all meetings of the Northwest Scientific Association, serving on the Council in 1929 and as Vice President in 1930. Had all of our members been as efficient in securing aid for the publication of NORTHWEST SCIENCE as has Dean Todd it might have escaped some of the difficulties which have beset it. In the Chemistry-Physics Section he has been the impersonation of faithfulness. The Association looks forward to another successful year under his leadership.

With this issue of Northwest Science a new departure is inaugurated. Editorial responsibility is being divided among experts in various fields, and, with this change, more specialized editions will appear. In the past several editions devoted to local science have appeared, and have been highly successful. The present issue comes chiefly from our Section of Public Health and Sanitation. In May several Forestry articles will appear, while the August number is in the hands of the Geology-Geography Section.

It is with no little editorial pride that attention is called to the quality represented on the Editorial Board. Every one is a hard worker and each is well up in his chosen field. In the group is an old-time printer who has volunteered to advise in this field. And no one knows the Northwest so well as our old colleague, L. K. Armstrong.

Not the least element of strength is a linotype operator who for two years past has loyally set up as nearly perfect proof as seems humanly possible. For the time being the present editor will continue as executive without push-buttons, desk or stenog, and nurse the hope that springs afresh, that the new set-up will inspire public confidence and support may come from the populace, which every slave of science hopes his work may serve, as well as from his confreres. whose efforts he seeks to aid. Unsparing criticism is invited.

MAR 3 1937

Grants-in-Aid of Research of N. W. S. A.

The Board of Trustees announces the following Grants in Aid of Research for the year of 1937:

Dr. Harold P. Klug, Moscow, Idaho, to continue his studies of Molecular Rotation in Solids, for which grant was made last year, $50.00.

Dr. Albin G. Matson, Missoula, Montana, to continue studies of Blood Groups of Flathead Indians, or which previous grant was made, $25.00.

Dr. J. H. Ramskill, Missoula, Montana, to continue studies of Climatic Adaption of Seeds of Geographic Strains of Pinus ponderosa, for which previous grant was made, $35.00.

Dr. Van A. Odle, Spokane, Washington, for purchase of apparatus for study of Cataphorific Velocities of Red Blood Cells in Health and Disease, $25.00.

The work of Drs. Klug, Matson and Ramskill have received notice in earlier issues of Northwest Science, and will receive further notice as their various projects progress. Dr. Odle is new to our group, and will be welcomed as a valuable addition. He has already made progress in his chosen research. Red blood cells in suspension in blood serum in an electric field move at varying rates of speed across the field to collect at the positive electrode. The rate of this movement can be measured under a microscope. Dr. Odle's study is of the rate in health and disease and anticipates results of diagnostic value.

Funds for these grants comprise a few local contributions and the grant of $50.00 made annually to Affiliated Academies of Science and Scientific Associations by the American Association for Advancement of Science. This constitutes the Trustees' Research Fund, contributions to which, of any amount, are welcome from persons desiring to aid scientific research. It is hoped that these contributions may be greatly increased in order that many more worthy projects planned or now in progress among individual workers in the Northwest may be given aid by the Trustees.

The Howard R. Flint Fund for Aid of Scientific Research is making fine progress. Contributions to this Fund have already passed one thousand dollars and are invested in dividend paying stocks. This is a permanent fund from which only the income will be used. As income accumulates and suitable projects are selected it will be paid out in "grants-in-aid."

Grants-in-Aid by A. A. A. S.

Harry F. Clements, Botany Department of Washington State College, and Albin G. Matson of Montana University at Missoula are recipients of $275.00 and $175.00 respectively from the Research Committee of the A. A. A. S.

Dr. Clements' work is on the "mechanism of freezing resistance in the needles of *Pinus Ponderosa* and *Pseudotsuga taxifolia.*

Dr. Matson is given aid to carry on his work among American Indians in Canada, extending his work on blood groups among Indians to the north, for which he received grants last year and this from Northwest Scientific Association.

As Northwest Science was going to press, word was received that the grant-in-aid of $50.00 given annually by the A. A. A. S is now available for 1937. This, together with a small additional sum on hand, will be given soon to aid some other research project in the Northwest. The A. A. A. S. grant is not limited to members of the N. W. S. A. or any other organization.

MAR 3 1937

SYMPOSIUM ON SELF-PURIFICATION OF SPOKANE RIVER

(Three Articles Appearing in This Symposium Were Read Before the Bacteriology-Public Health Section of Northwest Scientific Association, December 29, 1936)

The Sanitary Significance of the Spokane River

By A. D. BUTLER

Spokane City Engineer, Spokane, Washington

A frontier people need have no concern about the water they drink, nor where they dispose of their waste. Water generally is pure until it is defiled by man. But as civilization advances the polluted streams become a problem. Fifty years ago this problem became acute in the East, twenty years ago in the Middle West and today it confronts us.

There are many questions which have arisen from this situation that scientific men have tried with varying degrees of success to answer. One of these questions is: How quickly will a given stream or body of water recover from a given pollution load? This question has been the cause of a number of investigations by the U. S. Public Health Service, and among the very interesting and instructive bulletins to be had are studies on the Ohio, Illinois and Mississippi rivers.

During these studies, it was found that of the many tests that were made, the two that gave the most accurate picture of the extent of pollution were *B. coli* and biochemical oxygen demand. Studies on a very much less extensive scale than this made by the U. S. Public Health Service have been made for the past fifteen years on the Spokane River by local authorities, a full report of the findings of which are entirely too voluminous for such a paper as this. so we will deal in this paper only with the general characteristics of the Spokane River and a brief analysis of the findings and conclusions that can be drawn from the B. O. D. (biological origin demand) studies.

THE RIVER.

The Spokane River has its source in Coeur d'Alene Lake, a body of water about 30 miles in length and fed from streams having their origin in the mountains of northern Idaho and western Montana, the St. Joe, St. Maries and Coeur d'Alene rivers being the principal tributaries. From the source of the Spokane River to its outlet in the Columbia it travels a distance measured along its course of about 105 miles, and has a fall of about 1050 feet. From the lake to the City of Spokane, a distance of 30 miles, it flows through the Spokane Valley, a broad, gravelly and intensely cultivated valley, the greater part of which is under irrigation.

Below the city, the river is swift and flows mostly between high steep banks unsuited for farming, not only because of their steepness, but because of the poor sandy and rocky nature of the soil. There are flowing into the river only two tributary streams of any consequence: Hangman Creek, outletting just below the business section of Spokane, and the Little Spokane, about 15 miles below the city.

Although the rivers feeding into the Coeur d'Alene Lake have at times a combined flow estimated at over 100,000 cfs, the equalizing effect of the lake and its restricted outlet has resulted in a maximum flow in the Spokane River of a little less than 50,000 cfs. The low-water flow is regulated by the control works of the Washington Water Power Company—Post Falls Dam, and seldom is allowed to get below 1500 cfs.

A study of annual flow tables shows that there is only 10 per cent of the time

when the flow is less than 1700 cfs. During the low water month, the amount of water entering the river through Hangman Creek and the Little Spokane is so small that their influence may be ignored.

THE POLLUTIONS.

In the drainage area tributary to Coeur d'Alene Lake there is a population of approximately 22,000, only a comparatively small percentage of which, however, lives in cities of sufficient size to be served by sewers.

The first direct source of pollution entering the Spokane River is from Coeur d'Alene, a city of about 8,000 population, whose sewers enter just below the outlet of the lake.

The next source of pollution of any consequence is at Millwood, where the Inland Empire Paper Mill discharges its sewage and mill waste into the Spokane River. When the mill is running at capacity and all of the sulphite liquor is being discharged into the river, this plant has an estimated population equivalent of 115,000. During the past few years, however, a large amount of this waste liquor has been used as a dust palliative on Spokane City streets, which has greatly reduced the pollution entering the river from this plant.

During the low-water season, if none of this sulphite is dumped into the stream, the population equivalent of the plant is from 30,000 to 40,000.

The last and principal source of pollution is the sewage from the City of Spokane. The Spokane River divides the city into two equal parts, so far as population is concerned, and there are 25 subtrunk sewers entering the river at various places, from Sharp Avenue on the East to Assembly Street on the West. In addition to this, there are numerous small industries along the river bank which discharge their waste into the stream.

The estimate made by Mr. Greeley, Consulting Engineer, of the pollution load of the river as it leaves the city, predicated on the number of sewer connections, vaults and cess pools cleaned, kill of animals at the slaughter houses and B. O. D. basis for industries is as follows:

Item	Upper Estimates	Lower Estimates
1. Human population connected to sewers	60,000	60,000
2. Population equivalent of minor industries	30,000	30,000
3. Unsewered population	7,000	7,000
4. Major industries in city limits	80,000	35,000
5. Upriver industrial and miscellaneous	110,000	40,000
	287,000	172,000

In order to determine the characteristics of the sewage being discharged into the river, a number of samples taken from the principal sewers were analyzed, the results of which showed an average suspended solids of 220 ppm, and a five day B. O. D. of 230 ppm. The measured flow from the 25 sewer outlets showed an average total flow of 21.71 cfs. On this basis we have a total of 26,000 pounds of suspended solids and 27,000 pounds of B. O. D. in 24 hours discharge into the river. During the same time that these sewer samples were taken, a number of analyses were made of the Spokane River, the average of which showed a B. O. D. of the river above the city of 1.47 and below the city of 2.17, or a difference in oxygen demand of .7 ppm. During this period the average flow in the river was 6,000 cfs. If then, we use this as a basis, we have total pounds of water per 24 hours times .7, or 22,680 pounds of five-day B. O. D., a closer check perhaps than the data at hand might warrant.

SELF PURIFICATION.

The rate at which a polluted stream will rehabilitate itself, depends upon the quantity of oxygen it will absorb in a given time, and this in turn depends upon the area of water surface exposed per unit of volume.

In turbulent streams, the rate of reaeration is high because new surfaces of

water are being constantly brought in contact with the atmosphere. Such streams, however, carry the pollution a greater distance down stream before a given amount of self-purification is effected. The extent of self-purification then, which is brought about in a given distance, depends somewhat on the time it takes the water to reach a given point. This being true, let us now consider the length of time required for the water from Spokane to reach the Columbia and also the characteristics of the stream which would favor self-purification. After a few miles of rapid flow below the city, the river enters the backwaters of Nine Mile Dam. After passing through this and over the dam, it enters immediately into the backwaters of the Long Lake Dam and again into the backwaters of Little Falls Dam. From there the river is a rapid turbulent stream for a distance of about 25 miles to its outlet into the Columbia.

The characteristics of the river below the city may be tabulated as follows:

Pool back of	Volume in million cubic feet	Displacement time in hours for river flow of 1700 cfs.	Surface area of pool in thousand square feet.
Nine Mile	227	37	30,000
Long Lake	10,000	1630	210,000
Little Falls	185	30	8,000

The displacement of the pool waters back of the dams is very probably not complete and there are volumes along the bottoms and shores, where the displacement is caused by wind or cross currents, rather than river flow. Thus the time of flow through the pools is probably substantially less than the displacement time indicated above. The accompanying diagram shows the estimated time required for the water in the river to reach various downstream points and is predicated on 50 per cent of the total complete displacement.

We then have these two factors which are of vital importance in enabling the Spokane River to free itself from its load of pollution before it reaches the Columbia:

1. The time which is shown from the ac-accompanying curve to be about 40 days in low water.
2. The area of exposed water surface, including the pools back of the dams, which is estimated at about 250,000,000 square feet.

The rate of re-aeration of a stream depends on the amount of pollution it contains. The more it is polluted, the more rapidly it absorbs the oxygen of the air. The law which seems to be generally accepted is: If 20 per cent of the oxygen demand of a stream be satisfied in the first 24 hours, then 20 per cent of the remainder will be satisfied in the next 24 hours, and so on.

Studies made by the U. S. Public Health Service on the Mississippi River showed that re-aeration took place at the rate of five-tenths pounds of five-day B. O. D. per 1,000 square feet of surface per 24 hours. where the dissolved oxygen in the diluting waters was 60 per cent saturation. If this is true, then 250,000,000 square feet of exposed surface would be capable of supplying 125,000 pounds of oxygen per day, or about five times the 27,000 pounds required for Spokane sewage.

It is true that the dissolved oxygen in the Spokane River is somewhat higher than 60 per cent saturation and therefore the rate of re-aeration would be somewhat less. But even so, if we take the findings of the U. S. Public Health Service as applicable, we would be safe in expecting to find the waters of the river entirely recovered from its pollution load, considerably before it reaches the Long Lake Dam. Let us now see what actual analysis of the river revealed.

During 1933, 23 weekly samples were taken of the river at the low-water period, from June 6th to December 5th. These samples were analyzed for the following results: Five-day B. O. D., dissolved oxygen and total bacterial count on agar and colon.

We will assume in this paper that the five-day B. O. D. determination is an index of the extent to which the water in the Spokane River is able to rehabilitate itself in its flow from Spokane to the Columbia River.

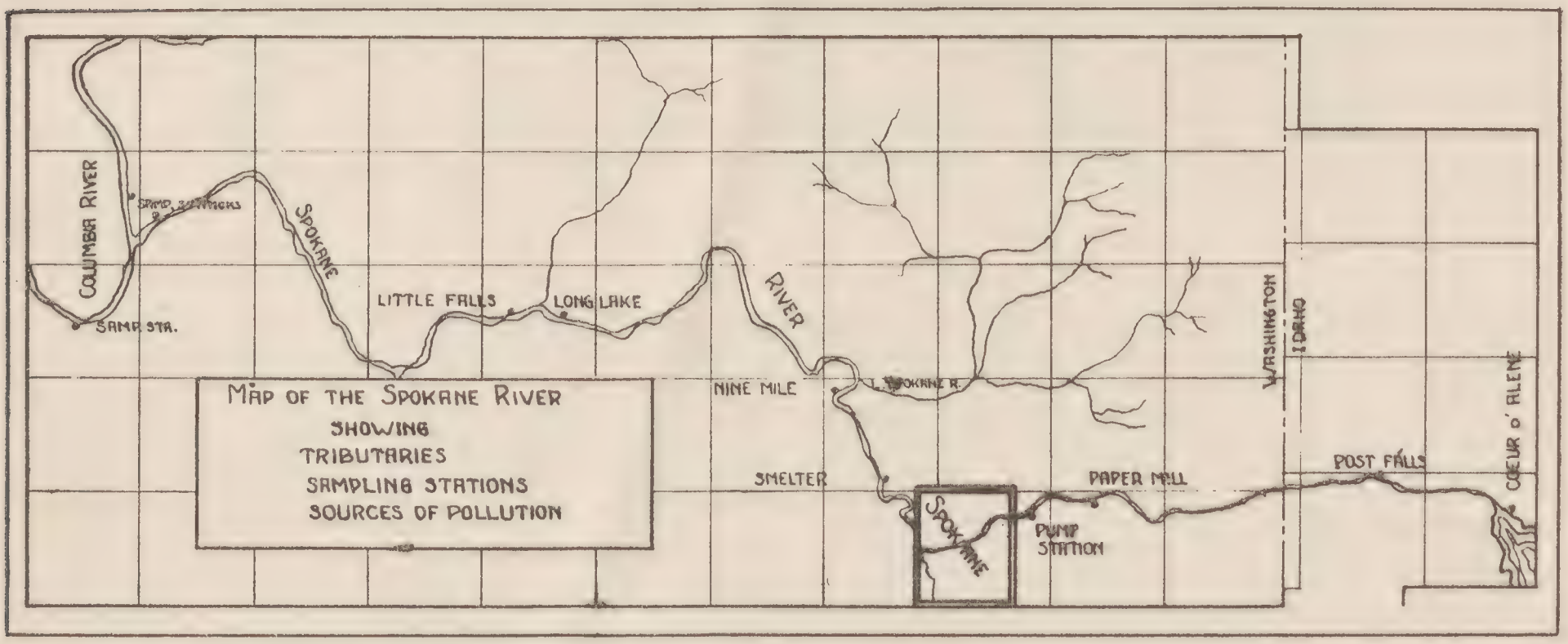
The average of these 23 samples taken are as follows:

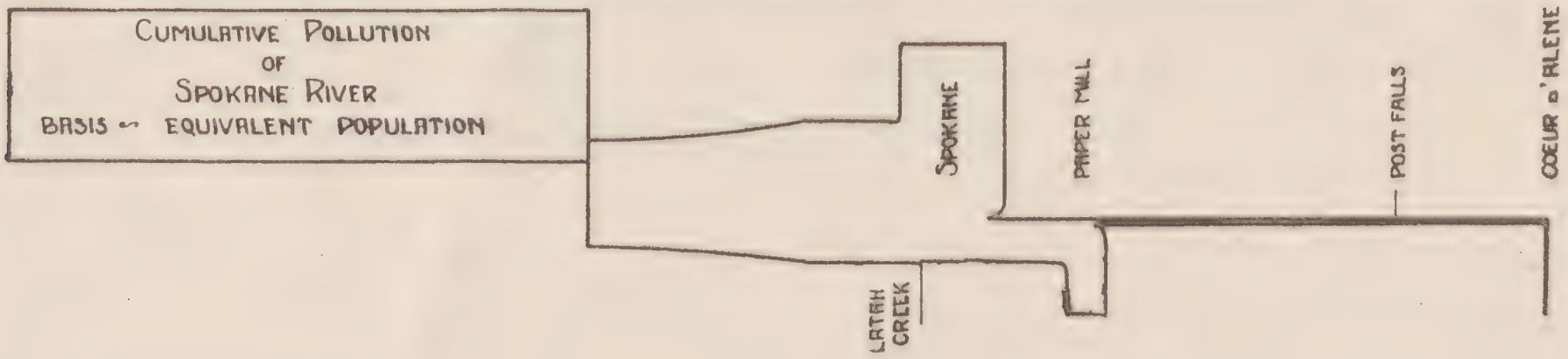
In the forebay of the City Power Plant above the city	1.47
At the head of the Nine Mile backwaters	2.17
At Nine Mile just above the dam	1.93
At the mouth of the Spokane River	1.40

The correct answer to a biological problem can only be had when sufficient data has been collected to justify a conclusion. The more data, the more nearly the right answer will be had, but no problem is complete without some kind of an answer, so with what data we have, the answer so far as B. O. D. studies are concerned, is that the Spokane River is the most heavily polluted as it enters the back waters of Nine Mile Dam, less heavily polluted at a point just above this dam and purer at its mouth than it is at the City Power Plant where it enters the city limits.

We then have two reasons to believe that the Spokane River at its mouth has entirely recovered its oxygen balance. First: From the findings of the U. S. Public Health Service, it is reasonable to expect. Second: From the average results of 23 samples it has actually taken place.

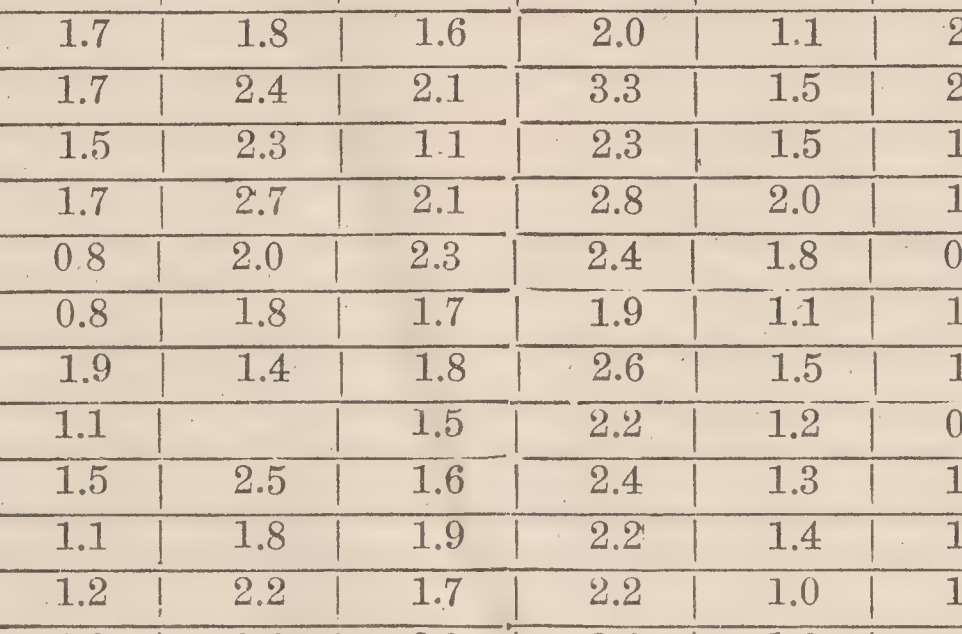
The scientific value of such studies as these can not be denied and it is the hope that the U. S. Public Health Service may be induced to take up these studies and carry them to completion, for there is no stream in the United States where the problem of self-purification is presented in as clean-cut a manner as is the case with the Spokane River.





BIOCHEMICAL OXYGEN DEMAND Five-Day Test 1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	0.05	2.65	0.64		0.62	2 53	2.5
Jun. 13	2.15	2.80	2.71		1.95	3.10	2.7
Jun. 20	1.5	2.1	2.6		1.8	3.6	3.3
Jun. 27	0.6	1.5	1.8		0.5	1.9	2.8
Jul. 3	1.4	1.8	1.2		1.2	4.0	3.5
Jul. 11	2.5	2.3	2.4		1.2	4.1	3.9
Jul. 18	1.4	1.8	1.5	2.2	1.6	2.8	2.2
Jul. 25	1.8	2.6	2.2	3.1	0.8	2.3	3.4
Aug. 1	1.7	1.8	1.6	2.0	1.1	2.5	2.5
Aug. 9	1.7	2.4	2.1	3.3	1.5	2.4	1.9
Aug. 15	1.5	2.3	1.1	2.3	1.5	1.9	0.9
Aug. 23	1.7	2.7	2.1	2.8	2.0	1.6	2.0
Aug. 28	0.8	2.0	2.3	2.4	1.8	0.8	1.5
Sep. 5	0.8	1.8	1.7	1.9	1.1	1.0	1.0
Sep. 12	1.9	1.4	1.8	2.6	1.5	1.1	1.4
Sep. 19	1.1		1.5	2.2	1.2	0.8	1.0
Sep. 26	1.5	2.5	1.6	2.4	1.3	1.4	1.1
Oct. 3	1.1	1.8	1.9	2.2	1.4	1.2	1 5
Oct. 10	1.2	2.2	1.7	2.2	1.0	1.1	1.1
Oct. 25	1.9	2.6	2.3	2.6	1.9	1.8	1.7
Nov. 7	1.1	2.0	2.3	1.8	0.8	1 4	1.0
Nov. 21	1.9	2.0	2.4		2.1	1.9	2.1
Dec. 5	2.5	2.7	2.6		2.3	1.9	2.6
Av.	1.47	2.17	1.93	2.40	1.40	2.05	2.07



DISSOLVED OXYGEN Parts Per Million 1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	9.60	11.68	10.35		10.10	13.05	12.60
Jun. 13	11.35	11.80	11 81		10.95	13.1	12.4
Jun. 20	10.4	11.7	11.2		10.7	13.3	12.9
Jun. 27	9.8	11.0	10.8		10.0	13.1	12.7
Jul. 3	10.2	11.4	10.8		10.9	13.9	13.7
Jul. 11	9.5	10.5	9.4		10.3	13.7	13.2
Jul. 18	9.0	10.1	9 2	9.3	10.2	13.2	12.6
Jul. 25	9.0	10.4	9.8	9.8	8.3	11.7	11.5
Aug. 1	8.7	9 5	8.4	8.8	9.2	11.5	11.5
Aug. 9	8.7	9.6	8.5	9.2	9.4	11.2	11.1
Aug. 15	8.5	9.3	8 0	8.2	9.3	10.8	9.7
Aug. 23	9.1	9.7	8.0	8.3	9.7	10.8	10.8
Aug. 28	8.7	9 3	8.3	8.0	9.5	10.6	10.4
Sep. 5	8.5	9.4	8.9	8.6	9.7	10.7	10.5
Sep. 12	9.0	9.5	8 8	8.9	10.0	11.1	10.4
Sep. 19	8.9		8.9	8.9	9.8	10.9	10.3
Sep. 26	9.2	9.9	9 5	9.4	10.2	11.2	11.1
Oct. 3	9.2	9.8	9.7	9.7	10.4	11.3	11.1
Oct. 10	9.2	9 8	9.4	9.2	10.5	11.2	11.0
Oct. 25	10.3	10.0	10.5	10.4	10.8	11.9	11.7
Nov. 7	11.2	12.3	12 2	12.0	11.6	12.7	12.4
Nov. 21	10.8	11.5	11.2		11.7	12.7	12.7
Dec. 5	11.3	11.9	11 4		11.6	13.2	12.9
Av.	9.57	10.4	9.82	9.25	10.20	12.04	11.7

GEOLOGICAL BULLETIN. Under date of February 15, 1937, Vol. 2, No. 5, of Professor George Beck's Geological Bulletin, appears. It is a little three-column sheet packed full of news of paleontology of central Washington. It is a bit difficult to be judicially calm about the work of this tireless worker. What he has done for this section in less than a decade in making geological history would seem much for a life-time. Seven or eight years ago he took the writer out from his laboratory in the Ellensburg Normal School to the Columbia River at Vantage and showed slivers of petrified wood found on the slopes of the canyon. These he followed back as a prospector would follow "float" until, finding here and there a buried stump, he has revealed forest on forest connecting the Miocene with the present. A CCC camp of workers have converted this area of rocky slopes into a

DISSOLVED OXYGEN

Per Cent Saturation

1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	96.4	117.2	103.9		97.9	124.2	121.0
Jun. 13	116.8	122.1	122.1		114.6	126.0	121.9
Jun. 20	110.0	123.6	119.8		114.5	129.0	126.7
Jun. 27	107.0	120.0	118.0		108.0	128.5	126.0
Jul. 3	111.5	124.5	118.0		116.5	140.0	139.0
Jul. 11	107.0	117.0	107.0		114.7	137.5	134.0
Jul. 18	102.5	111.6	103.5	103.9	105.6	136.6	139.0
Jul. 25	100.2	112.3	111.6	111.6	96.3	122.5	121.9
Aug. 1	95.1	99.5	94.5	99.1	104.4	121.8	120.4
Aug. 9	97.2	102.8	94.8	103.5	106.9	119.7	119.0
Aug. 15	95.8	101.5	89.2	96.0	103.5	112.3	106.0
Aug. 23	99.3	100.6	87.4	96.3	107.0	116.7	116.7
Aug. 28	96 0	98.5	91.7	88.4	105.0	114.7	111.1
Sep. 5	90.8	98.4	95.2	92.0	103.8	112.2	110.0
Sep. 12	94.2	99.4	92.1	93 2	108.0	116.2	107.7
Sep. 19	92.3		92.3	92.3	102.5	111.8	105.5
Sep. 26	90.3	94 0	90.2	89.2	100.2	110.1	109.2
Oct. 3	91.4	95.3	95.2	95.2	104.5	111.0	109.0
Oct. 10	92.3	97.4	94 3	92.2	102.1	110.0	106.7
Oct. 25	100.1	97.2	102.0	101.1	101.5	109.5	108.8
Nov. 7	102.9	113 0	113.2	111.4	102.3	111.7	110.0
Nov. 21	96.8	103.1	101.4		105.3	109.0	110.2
Dec. 5	95.0	103.1	97.2		99 4	110.2	109.3
Av.	98.3	106.9	101.5	97.7	105.4	119.3	116.9

great outdoor museum: a Gingko National Monument. Not satisfied with these, he is now filling his bulletins with Rhinoceri, Camels, Elephants, Hiparion, Bison and many smaller mammals represented by bones found here and there in the Great Bend, Yakima and Kittitas sectors by many delighted contributors.

In progress in The Mineralogist of Portland, Oregon, is a series of articles on 'determination' of petrified woods. Soon to appear will be "Camels of the Columbia Plateau" from Professor Becks' pen.

Oh, George, please give some of us envious ones, who exhaust ourselves with our daily round from home to classroom, "a shot of the same" which enables you to have eyes to see in every part of an area as big as Indiana and energy left to write and teach.

Studies on Sewage Pollution of the Spokane River and an Estimation of the Degree of Hazard to Health

By W. ALFRED BUICE, M. D., DR. P. H.,

Director of Laboratories and Research, Eastern State Hospital, Medical Lake, Washington

Since the classic and now historic work of Professor E. O. Jordan in his bacteriological investigation of the health problem formed by the Chicago Drainage Canal and the Illinois River in the 1890's, several streams in this country and in Europe have undergone similar investigations. But so far as the writer is aware all these streams were of a very turbid, slow moving character and the bacteriological and chemical investigations were complicated by the fact that a number of sewerage systems emptied their contents into those rivers at various intervals down their courses. Besides, so far as the writer recalls, none of those rivers were vastly polluted at their sources with enormous quantities of waste materials from great mines, which might conceivably produce great changes in mineral content of the waters and might cause decided changes in hydrogen-ion concentration and which in turn might effect bacterial, protozoal and other forms of life that usually are found associated with sewage.

The Spokane River differs decidedly in a number of respects with those streams which have experienced thorough investigations. Its source is a large lake much polluted by mines. Yet, the water of the river is exceedingly clear, as waters of rivers go. Except for the occasional artificial lakes formed by dams along its course, the waters of the Spokane continuously tumble over great boulders and rush in great sprays down cataracts, thus retaining a high degree of oxygenation potential. It is said by some to possess one of the steepest gradients of the world for rivers of its size, the fall averaging ten feet per mile. After the sewage of Spokane City's population of 140,000 is emptied into the river no other sewage of any proportion enters the stream during the rest of its source, a distance of something like 70 miles below the city. The Spokane River thus offers an unique opportunity for chemical and bacteriological investigations.

In the experimental work recorded in this paper no pretense is made of having done an exhaustive study of the Spokane River. Very far from it. Indeed, only one phase of the problem was touched, and that one inadequately. The writer has confined himself chiefly to the longevity of, and distance traveled by, the Coli-Aerogenes group of intestinal bacteria in Spokane City's sewage, due to limited time, for the writer was doing this project in addition to his regular duties being performed at Eastern State Hospital. Not only that limitation, but he also has limited the number of sites for sample-taking to only four stations. Besides, this topic should be studied during the cold half of the year, as well as during the warm half; and it should be studied while the river is running full, as well as when it is low. Moreover, sampling should be done at the source of the river, after each additional pollution is poured into the stream in its upper stretches, at the upper ends and lower ends of the artificial lakes, and on the Little Spokane River which perhaps contributes a slight amount of sewage a few miles below the city. Altogether there should be about 17 sampling stations instead of four. Furthermore, a study should be made of the sedimentation, plankton, oxygenation, hydrogenation concentration and other factors which influence the disappearance of bacteria. But these would require years of time. However, the limited study recorded here appears to give clear indications of a certain few facts.

THE SAMPLING STATIONS.

Four sampling stations were selected.

NUMBER OF COLI-AEROGENES GROUP PER CC OF WATER

Date	Upper River		Lower River	
	Millwood	7-Mile Bridge	Lincoln	Columbia River (above junction)
	Per cc	per cc	per cc	per cc
May 28	0.1	10		
May 31			0.1	0
June 4	0.1	10		
June 7			0.1	0
June 11	0.1	10		
June 14			0.1	0
Missed two weeks here				
July 2	1.	10		
July 5			1.	0.1
July 9	0.1	10		
July 13			1.	0
July 16	1.	10		
July 19			1.	0.1
July 23	1.	100		
July 26			1.	0.1
Missed a week here				
Aug. 6	1.	100		
Aug. 10			1.	0
Aug. 13	1.	100		
Aug. 17			10	0
Aug. 20	1.	10		
Aug. 23			1.	0
Aug. 27	1.	100		
Aug. 31			1.	0.1
Sept. 3	0.1	100		
Sept. 6			0.1	0
Sept. 10	0.1	100		
Sept. 13			10	1.
Missed this week				
Sept. 24	1.	100		
Sept. 27			0 1	0
Oct. 1	1.	100		
Oct. 4			1.	0
Oct. 8	1.	10		
Oct. 12			1.	0
Missed two weeks here				
Oct. 29	1.	100		
Nov. 2			1.	0
Nov. 5	1.	100		
Nov. 8			1.	0
Averages	0.7	60	1.7	0.08

The first station, furthest up-stream, was about 200 yards above the paper mill at Millwood. This station was located some 300 yards up-stream from the eastern city limits of Spokane. The second sampling station selected was the site of the Seven-Mile Bridge, west and down-stream from the city limits, and located some four miles below the last of the city's sewer outlets. The third station was at the Lincoln Bridge, near the hamlet of Lincoln and about one mile from the junction of the Spokane and Columbia rivers. The fourth was on the Columbia River at a ferry about two miles up-stream from the junction of the rivers.

Samples were taken at Millwood and Seven-Mile Bridge on Thursdays of each week, and on the following week-end samples were collected at Lincoln Bridge and from the Columbia at the ferry. Thus samples were collected from all stations each week between May 28 and November 8 of this year (1936), with the exception of certain weeks indicated in the accompanying table. All samples were carried immediately to the laboratory of the Eastern State Hospital at Medical Lake where they were run.

TECHNIQUE.

The methods and technique employed were essentially those described in "Standard Methods of Water Analysis," Eighth Edition (1936). Graduated quantities of the water were pipetted into standard lactose broth tubes. The quantities were as follows: 10 cc, 1 cc, 0.1 cc, 0.01 cc, 0.001 cc, 0.0001 cc, and 0.00001 cc. The smallest of these quantities revealing gas at the end of 24 hours to 48 hours of incubation at 37 degrees C. was looped to plates of both Endo and Eosin-Methylene Blue agars. After 24 hours to 48 hours of incubation typical coli-aerogenes colonies appearing on either agar were fished into fresh lactose tubes. Those tubes showing gas at the end of 24 hours to 48 hours were planted in nutrient agar slants and the growth was Gram stained. Additional media for the confirmed and completed tests were not used, because of limited time of the writer. Media for distinguishing the *B. coli* members from the aerogenes subgroup were not used. No effort was made to distinguish so-called fecal and non-fecal subgroups because of limitations and uncertainty of present knowledge in that field. Difco dehydrated media were used.

RESULTS AND CONCLUSIONS.

Results obtained are shown on the accompanying table. Please refer to the averages at the bottoms of the four columns in the table. It will be noted that the average number of coli-aerogenes bacteria found per cc of water at Millwood was 0.7 bacterium per cc of water, while the average for Seven-Mile Bridge (below City of Spokane) was 60 bacteria per cc. This indicates that the city adds about 85 times as much sewage to the river as is contained in the stream when it enters the city from the east.

Considering the averages of the third and fourth columns it will be seen that the concentration of the coli-aerogenes organisms in the Spokane River near its mouth is about 22 times as great as in the Columbia River up-stream from the junction of the two.

A glance at the first and third columns shows that more sewage reaches Lincoln (near the mouth of the Spokane) than enters the City of Spokane.

Comparing the averages of the second and third columns, it appears that approximately one thirty-fifth of the coli-aerogenes bacteria in Spokane's sewage reaches the Columbia River. It is well known that the members of this group and the typhoid bacterium compare very favorably in their capacities to resist the unfavorable living conditions outside the human intestine. Therefore, we may justly infer that some of the typhoid organisms which find their way into Spokane's sewerage system must ultimately reach the Columbia River. In other words, theoretically, at least, there is a potential danger of Spokane's sewage carrying typhoid to swimmers and the thirsty as far as the

confluence with the Columbia.

Yet, it must be recalled that *B. typhosus* is in the discharges of patients and carriers in exceedingly small numbers as compared with the enormous numbers of the coli-aerogenes group. Considering the number of the latter group in the water at Lincoln, we must conclude that the chance of ingesting a typhoid bacterium originating in the City of Spokane is an almost infinitesimally small one. But by the same course of reasoning the likelihood of becoming infected with the bacterium at Seven-Mile Bridge must be considerable.

However, it becomes proper here to remark that in all probability it is comparatively infrequent that typhoid bacilli find their way into the Spokane sewerage system from cases of the disease, for cases of typhoid are not frequent in the Spokane territory as compared with other sections of our country. And it is probable that there are very few typhoid carriers in Spokane and adjacent territory, because there have been very few cases experienced. In Alabama where many cases are experienced annually, Havens[1] and his coworkers found about 5 per cent of healthy persons to be typhoid and paratyphoid carriers. Buice and Finger[2] working in Oklahoma found 4 per cent of healthy dairymen to be carriers. But one might very reasonably surmise that an examination of Spokane's population would disclose a markedly contrasting condition, as regards number of carriers.

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Discussion on Natural Purification Processes in Watercourses

By ROY M. HARRIS, M. S., C. E.

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Self-purification may be defined as the natural process or combination of natural agencies that tend to render stable and innocuous foreign substances that find their way into water and so restore, or partial y restore, the water to its natural condition of purity. In the process of rendering innocuous these foreign substances which have been introduced into natural waters, many agencies are at work and many factors must be considered. These factors or forces may be divided into three general divisions: First, physical forces; second, chemical forces; and third, biological forces.

The physical forces may be subdivided into the effects produced by:

(1) GRAVITY. Heavy suspended particles and colloidal materials are removed by the processes of sedimentation, conglomeration, and coagulation;

(2) LIGHT. This promotes photosynthesis and in turn is responsible for the production of oxygen and the removal of carbon dioxide. In addition to this phenomenon, sunlight also aids in bacterial removal and the reduction of color by bleaching;

(3) HEAT. Increases in temperature promote chemical and physical forces and, in addition, temperature plays an important part in the bacterial reduction of polluted waters;

(4) AERATION. This important factor aids in the interchange of gases between the atmosphere and the inter-

face of the water. This is a particularly vital force, as sewage laden waters create a demand on the dissolved oxygen content of a stream which is known as deoxygenization, but through the reaeration or interchange of gases reoxygenization takes place and tends to aid in rehabilitating polluted streams.

The second general classification, chemical forces, may be subdivided into three parts as follows:

(1) OXIDATION. By this process aerobic organisms convert complex chemical substances into mineral matter, gases, or relatively stable organic matter. In addition, dissolved mineral matter such as iron and manganese may be oxidized and precipitated as insoluble compounds;

(2) REDUCTION AND HYDROLYSIS. By this action, hydrolysis, or splitting factions, assist to place mineral matter in solution, and anaerobic organisms pave the way for later stabilization by oxidation;

(3) COAGULATION. The mixing of certain wastes with sewage, particularly industrial wastes, has a tendency to assist in coagulation with a resultant precipitation of dissolved, collodial and suspended matter. Under chemical forces might also be added a fourth classification which is effective in the presence of certain industrial wastes such as arsenic, copper, and chlorine which aids in the reduction of bacteria by the process of disinfection.

The third general classification, which is biological forces, may be subdivided into a number of classifications each of which contributes vitally to the phenomenon of self-purification.

(1) BACTERIA. The food habits of these and other living organisms result in the decomposition and stabilization of sewage and other wastes by biochemical means. When the available food in the waters has been exhausted, or the wastes from their own existence render the environment unsuitable for habitation, each distinct group which may in turn flourish and then disappear.

(2) ALGAE. The plant forms such as algae and fungi utilize the simple chemical substanies that result from bacterial activity. Green plants by the action of photosynthesis give up oxygen and absorb carbon dioxide.

(3) PROTOZOA. These animal forms act as scavengers and aid in reduction of organic pollution.

(4) ROTIFERA AND CRUSTACEAE. These animal forms are also scavengers by nature and, in addition to consuming organic matter, their presence may account for a decrease in algae and protozoa.

(5) LARGE AQUATIC PLANTS AND ANIMALS. The larger plants are similar to algae in their effect inasmuch as they use up carbon dioxide and give off oxygen. The large aquatic animals such as sludge worms and other larva thrive in bottom deposits and in this manner assist in the destruction of organic pollution.

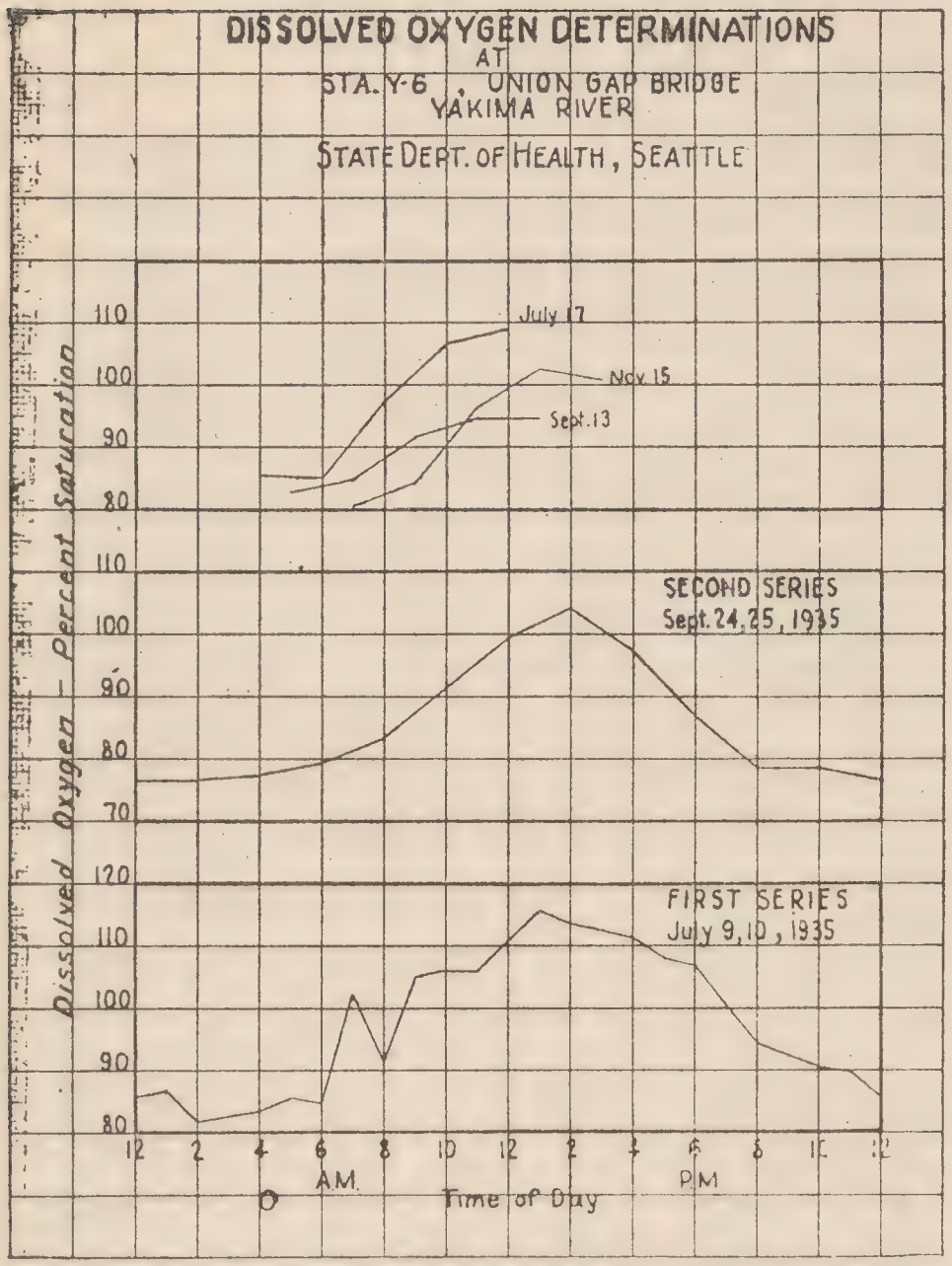
With these natural forces in mind it may be well to consider specifically the part that some of them play in the process of self-purification. Mr. Butler has presented a paper which deals with self-purification of the Spokane River as shown by the biochemical oxygen demand. In connection with his paper it may be well to consider what is meant by the biochemical oxygen demand, or B. O. D. The B. O. D. of a sample is a measure of the oxygen consuming requirements over a definite period of incubation and represents a portion of the demand that putrescible matter would make upon the dissolved oxygen content of a stream. A strict mathematical representation may be made of the first stage of the deoxygenization curve and the resultant equation takes the form of the well-known unimolecular reaction which

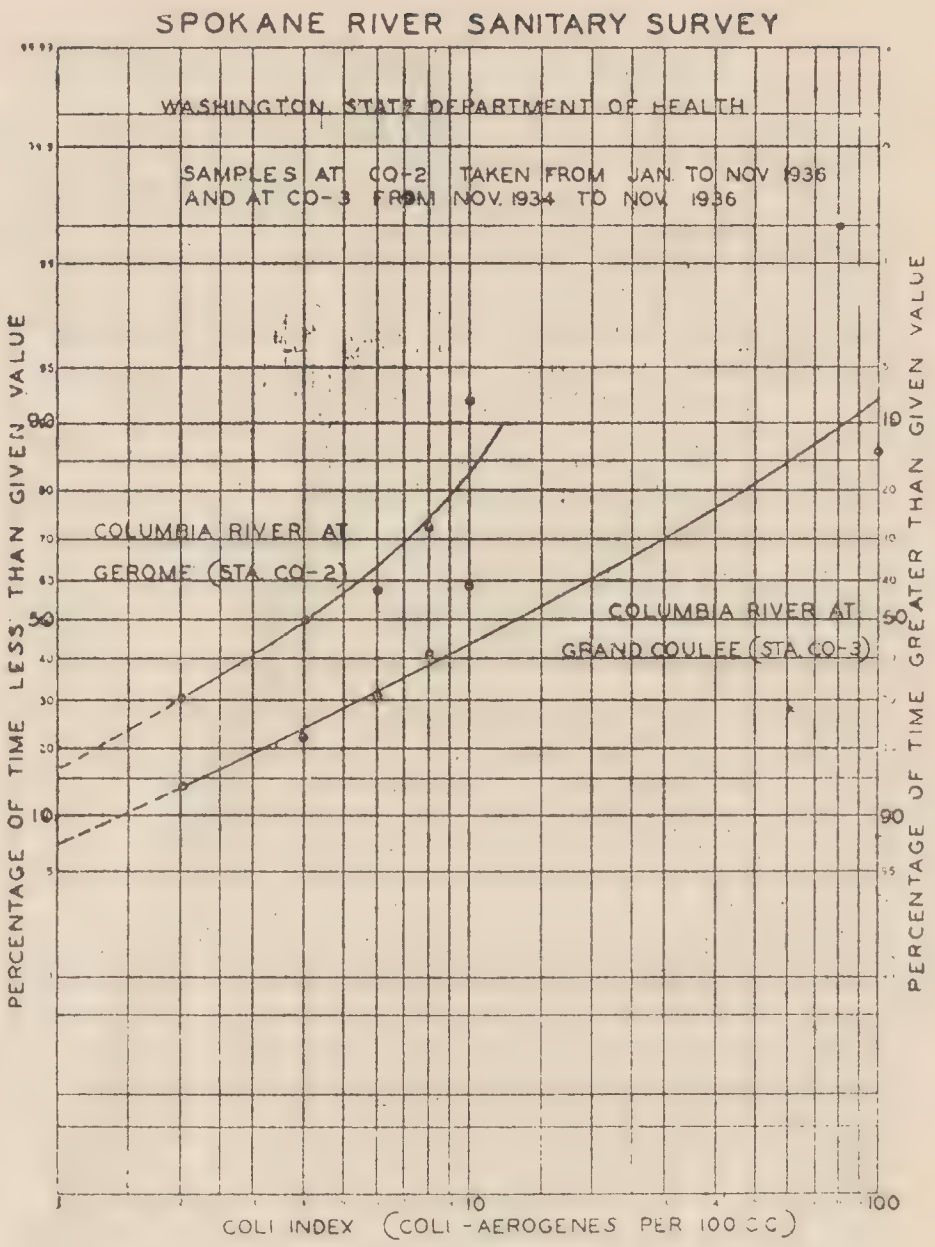
is familiar to all chemists, biologists, and bacteriologists, as the velocity of the reaction is controlled by the concentration of the oxygen requiring substances. In this equation the variables are temperature and time. The effect of temperature is reflected in the reaction coefficient, and time affects the amount of reacting substances that may be converted. The true deoxygenization curve of any polluted water is divided into two stages. The first stage involves the oxidation of carbonaceous matter, and the second stage involves the nitrification of nitrogenous matter. In general practice it is sufficient to determine only the first stage oxidation of the carbonaceous matter.

The activity of algae in the reaeration and rehabilitation of polluted waters has long been recognized, but quantitative studies on the amount of oxygen contributed by these microorganisms is extremely scarce. They may, in some instances, play a more important part in reaeration than does the exposed surface area of the water and, although the amount of oxygen which they contribute may be difficult to determine, their effects should not be neglected. In a study made by the U. S. Public Health Service into conditions of the Potomac River immediately below Washington, D. C., it was observed that at the point of maximum oxygen depletion, the average oxygen values were 15 and 26 per cent of saturation for the surface and bottom water respectively. Four miles below, the values were 65 and 60 per cent respectively and at the same time there was a reduction of bacteria and of the coli-aerogenes group of about 99 per cent. This is a striking example of the effect played by photosynthesis on self-purification of streams. Another striking example of this phenomenon may be taken from an investigation made in the State of Washington. During the summer and fall of 1936, while investigating pollution of the Yakima River, the State Department of Health found that twenty-four hour cycles of dissolved oxygen taken at the Union Gap bridge immediately below the City of Yakima showed a daily variation in July from 85 per cent saturation to 116 per cent saturation, and in September when algal activity had been somewhat decreased, the variation was from 76 per cent to 104 per cent saturation. The minimum saturation occurred between midnight and 2 A. M. and the maximum saturation between noon and 2 P. M. These cycles are represented by Figure 1.

It is important to remember that temperature is a controlling factor in removing bacteria, and it is also important to emphasize again that all natural purification processes are primarily functions of time. With this in mind it is easy to see why a rapidly moving stream will distribute pollution and bacterial contamination a much greater distance than will a sluggish stream or pond. A classical example dealing with the influence of temperature on typhoid bacilla was made by Houston. In this experiment he shows that 46 per cent of the bacteria remain alive after one week at a temperature of zero degrees centigrade, only 14 per cent at 5 degrees centigrade and only 0.07 per cent remain after one week at a temperature of 10 degrees centigrade. The U. S. Public Health Service in their studies on the Ohio River found that 30 per cent of the original number of bacteria remained alive after 100 hours of flow during the winter months, but only about 8 per cent remained alive after the same period of flow during the summer months.

Another investigation being conducted by the U. S. Public Health Service which will have a definite bearing on our interpretation of bacterial number in polluted waters is the experiment dealing with the effects of dilution on a polluted water. One series of carefully conducted experiments showed an initial increase in bacterial density when a highly polluted water was diluted with a less polluted water and the ratio of increase was greater with the higher dilutions. There have,

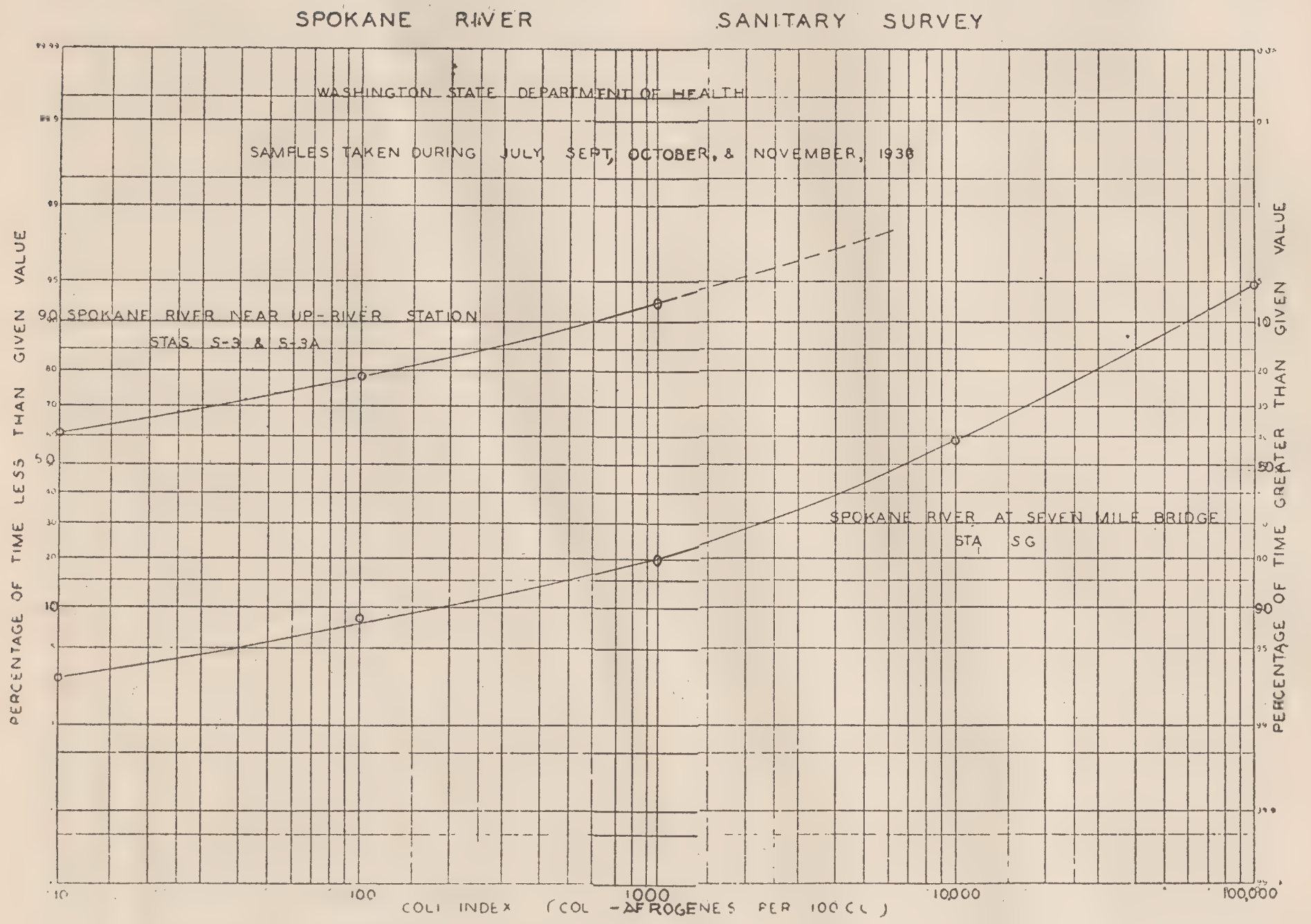



SPOKANE RIVER SANITARY SURVEY
WASHINGTON STATE DEPARTMENT OF HEALTH
SAMPLES AT CO-2 TAKEN FROM JAN. TO NOV. 1936
AND AT CO-3 FROM NOV. 1934 TO NOV. 1936
COLUMBIA RIVER AT
GEROME (STA. CO-2)
COLUMBIA RIVER AT
GRAND COULEE (STA. CO-3)
PERCENTAGE OF TIME LESS THAN GIVEN VALUE
PERCENTAGE OF TIME GREATER THAN GIVEN VALUE
COLI INDEX (COLI-AEROGENES PER 100 C.C.)
10
100

however, been few detailed explanations of bacterial reduction which take into effect all of the factors involved. Hoskins and Mutterfield of the U. S. Public Health Service, in explanation of the phenomenon of increase following dilution, state that dilution reduces both protozoa and bacteria by the same ratio, but the combination of reduced numbers in shorter generation time of the bacteria as compared with the protozoa, give an advantage to the former which results in an initial and temporary increase. The decrease, however, is produced by the fact that for any given concentration of nutrient material there is a self-imposed upper limit of the bacterial density, and that with dilution this upper limit is not reduced as rapidly as the reduction in nutrient concentration.

In connection with studies made by the State Department of Health on the Spokane River, probability curves based upon bacteriological samples have been prepared (Figures 2 and 3), and it is interesting to observe the influence of Spokane's sewage on the bacterial life of the river. At the Up-River pumping station above Spokane, samples taken during July, September, October and November indicate that a coli index of 100 should only be exceeded 22 per cent of the time. While at the Seven Mile bridge below Spokane it shows that for the same percentage of time the coli index should be 28,000, and for a coli index of 100 the value would be exceeded 92 per cent of the time.

On the Columbia River, samples were taken at Gerome from January to November, 1936, and at Grand Coulee near the intake of the Mason City water supply they were taken from November, 1934, to November, 1936. Probability curves for these two stations indicate that a coli index of 10 would be exceeded 56 per cent of the time at Grand Coulee, but would only be exceeded 17 per cent of the time at Gerome. Or, looking at these data in a different manner, for 50 per cent of the time the coli index at Gerome should be approximately 4, and for the same period of time at Grand Coulee it should be approximately 13.


SPOKANE RIVER SANITARY SURVEY
WASHINGTON STATE DEPARTMENT OF HEALTH
SAMPLES TAKEN DURING JULY, SEPT, OCTOBER, & NOVEMBER, 1936
SPOKANE RIVER NEAR UP-RIVER STATION
STAS. S-3 & S-3A
SPOKANE RIVER AT SEVEN MILE BRIDGE
STA. S G
PERCENTAGE OF TIME LESS THAN GIVEN VALUE
PERCENTAGE OF TIME GREATER THAN GIVEN VALUE
COLI INDEX (COL-AEROGENES PER 100 CC)
10
100
1000
10,000
100,000

In considering statements previously made in this discussion, it may be possible that the bacterial increase at Grand Coulee may be attributed to the effects of dilution. However, the respective conditions of the two streams are so near comparable as measured by the organic load (biochemical oxygen demand) that the writer is inclined to reject the dilution theory in this case when accounting for bacterial increase in the Columbia River below the mouth of the Spokane River. Another interesting observation in connection with bacteriological samples which ties in with the fact that self-purification is a function of time shows that the majority of the high coli-aerogenes tests at Grand Coulee occur during the periods of peak flow in the Spokane River when the time of detention between Spokane and Grand Coulee is materially reduced over that occurring during the summer.

In conclusion, the writer wishes to point out the fact that self-purification of streams may be measured by several tests or series of tests, and no one "yardstick" should be used to determine the degree of pollution. If the problem involves fish life or general comfort, oxygen depletion and the biochemical oxygen demand may be the controlling tests; if industrial use is considered then chemical examinations may be used for a guide; but for uses involving the public health, such as drinking water supplies and swimming, the most significant test is for bacteria of the coli-aerogenes group. These are the fecal type organisms that indicate sewage pollution, and their density and death-rate are highly significant to the public health worker.

Insect Immigrants in Washington*

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It is a well established fact in the field of economic entomology that most of our destructive insects are those which have come to us from other parts of the world. This is even true in the case of those two insect pests which cause the fruit growers of the Pacific Northwest more trouble than all the rest of them put together, i. e. the codling moth and the San Jose scale. The latter insect was not known to fruit growers in North America until some 40 years ago, while many of the older generation of fruit growers may recall those days early in the development of the irrigated regions in eastern Washington when the codling moth had not yet become established in many isolated locations.

On account of its geographical location, the state of Washington has experienced many additions to its insect fauna. Not only have foreign insects become established on our west coast but other introduced insects, which years ago had become established in eastern North America, have invaded the state from that direction. No doubt the vigilant eyes of the port inspection service of the Bureau of Entomology and Plant Quarantine have checked the introduction of many would-be insect pests. But when these insects advance in a solid front, which may actually be several miles in width, they will cross over international boundaries despite the efforts of inspection officials, custom officers, or even armed guards.

Several years ago, in company with officials of the Washington State Department of Agriculture, I attended a conference in British Columbia where entomological representatives of the Dominion government were making a study of the pea moth, a destructive insect which had become established in several counties in western Washington. Although this insect has been known to exist in Whatcom county for at least eight years, we are not entirely certain whether the pest became first established in Washington and advanced across the border into British Columbia or whether the movement was in the opposite direction. At the conference which I have just mentioned there was considerable raillery with our Canadian friends, since neither we nor they particularly desired to take credit for the first establishment of this destructive insect. Known in eastern Canada, in Michigan and Wisconsin, the only records we have of this insect in the United States west of the Mississippi are in four counties in western Washington. The pea moth seems to have slowly advanced toward the south and has already reached northern Snohomish county. Once established in an area where peas are grown, either for seed or for canning, the insect soon becomes sufficiently abundant to cause tremendous losses. These losses have been reduced, however, in areas where the entire acreage is restricted to the production of peas for canning.

Ten years ago before this group I reported on the known distribution of the wheat midge, *Thecodiplosis mosellana* which at that time had reached Snohomish county, having come in from the north, first recorded on the west coast in Vancouver, British Columbia, in 1904. Since that time the wheat midge has slowly extended its range and this year was reported as occurring near Puyallup. Since there are few wheat fields in the territory northward from Puyallup, the spread of the insect is considered as having been accomplished under rather adverse conditions. Since more wheat is grown further south, it seems likely that the further

* Read before Biological Section Northwest Scientific Association, December,

distribution of the wheat midge would be more rapid than has been the case since the insect first became established on the west coast. The insect was first observed in the United States in 1820 when it was found in Vermont. It is supposed to have been introduced into eastern Canada from England early in the nineteenth century.

Another dangerous insect imported from Europe, the Satin moth, *Stilpontia salicis* first appeared in Washington at Bellingham in 1921. Previously the insect had become established in British Columbia. Ten years ago the insect had come as far south as Seattle and in 1926 was conspicuous because of its destruction to foliage on Lombardy poplars on the campus at the University of Washington. By 1929 the satin moth had reached Olympia and has now traversed the entire distance across the state and reached Oregon. Though the satin moth became established some time back in the New England states, it does not occur elsewhere in North America except in Washington and in adjacent areas in Oregon and British Columbia.

An insect known as the carrot rust fly, *Psila rosae*, represents still another invader, although this particular pest occurs in eastern Canada, in New York state, in Massachusetts, and as far west as Michigan. It was first noticed in 1929 in the vicinity of Fife near Tacoma attacking carrots on the grounds of some of the Japanese gardeners. Since 1929 the carrot rust fly has moved northward into King county, across Snohomish county and has become firmly established in Skagit county. To the south the insect now occurs at Centralia. No one knows how the carrot rust fly was first brought into the state, although it is surmised that infested carrots in the eastern part of the country shipped to Tacoma or Seattle may have been responsible for the establishment of the insect on the west coast. Here again is a case of another insect which has come to us from Europe, although it has been known in eastern Canada since some time in the eighties.

During the last two years potato growers in the Yakima Valley have had an insect problem on their hands in the potato flea bettle, *Epitrix cucumeris* I think I can say without fear of contradiction that the establishment of these insects in the potato growing districts of the Yakima Valley is the most serious event that has occurred since potatoes were first grown in the irrigated districts of eastern Washington. The insect appears to be identical with our native species which occurs commonly east of the Rocky Mountains, although unknown on the west coast until its first appearance in Grays Harbor and Pacific counties in 1925. Since that time *Epitrix cucumeris* has been steadily increasing its range to the east through Thurston and Pierce counties, south to Lewis county and northward through Mason, King, and Snohomish counties. According to recent reports this insect has become established in Oregon. At a meeting of potato growers held in Spokane this fall, it was very evident that Idaho growers were much concerned over the possibility of this insect further extending its range and becoming established in the state of Idaho.

For a long time the Colorado potato beetle, *Leptinotarsa decemlineata*, was unknown west of the Rocky Mountains. Its first appearance in Washington seems to have been about 1910. It is said to have appeared in Walla Walla for the first time in 1915 and the first notice of the insect in Spokane was in 1918. In recent years the Colorado potato beetle has worked its way up the Yakima Valley and potato growers in the vicinity of Wapato and Toppenish have had to adopt spraying practices in order to prevent defoliation by the larvae of the Colorado beetle. The insect is not known west of the Cascades, although I have seen one specimen in the collection of the Oregon State Col-

lege at Corvallis, which, according to the label, appears to have been collected at Portland.

The first record of the asparagus beetle was in 1924 when it was observed at Yakima by M. A. Yothers. Since that time this particular insect has been collected elsewhere in the Yakima Valley, in Walla Walla, along the Columbia River to Clarke county, and northward on the coast as far as Auburn. Asparagus plantings in the vicinity of Kennewick were threatened by this insect several years ago following a mild winter which brought the beetles out of hibernation in tremendous numbers early in spring.

Another European insect, the elm leaf beetle, *Galerucella luteola,* established in the eastern states, was unknown in this section of the country until 1917, when it was first reported at Lewiston, Idaho. By 1919 the elm leaf beetle had reached Vancouver, Washington. In 1923 it was reported from Chehalis. In eastern Washington the insect attracted attention at Pasco in 1928 and has become firmly established in the Yakima Valley, in Dayton, Walla Walla and vicinity.

A tiny European moth which attacks lilac and privet in western Washington, *Gracellaria syringella,* has spread rapidly in recent years. In 1923 this insect was reported in Mount Vernon and La Conner in Skagit county, at Kirkland in King county, and in Port Blakely in Kitsap county. Following this the insect was reported in Seattle and in 1926 at Tacoma. By 1930 the lilac miner had reached Kelso and in 1934 was reported in two locations in Clarke county. Apparently the lilac miner has not yet invaded eastern Washington.

One more insect needs mention, the turnip seed weevil, *Ceutorhynchus assimilis,* first reported from North America during the past year and so far confined to limited areas in Washington, Oregon, and British Columbia. This insect recently has caused heavy loss to cabbage and turnip seed plantings in Skagit county, where the bulk of these seeds used in the United States is raised. Unless some means of checking this important pest are devised, the valuable seed growing industry in western Washington may be forced to move elsewhere in order to survive.

The Christmas Ceremonies at Quileute, Washington, in 1906

By ALBERT B. REAGAN, PH. D.
Department of Anthropology, Brigham Young University, Provo, Utah
(U. S. Government Official in Charge of the Hoh and Quileute Indians from 1905 to 1909)

At 8 o'clock Christmas evening four men with heavy hammers commenced pounding an iron watertank of an old wrecked vessel on the beach at the Indian village of Quileute, LaPush, Washington. A few minutes later a herald rushed to the residence of the government officials of the place and asked them in the name of the tribe to attend the native Christmas ceremonies in the "potlatch" (native town) hall of the village.

Already was the big hall crowded when the government people arrived, the women having one side of the house, the men the other. At once, then, a Klukwalle dance ceremony was begun, which, together with the continuous pounding of boards to keep the time, sounded much like the roaring of a mighty storm accompanied by a continuous thunder. The large door of the hall swung open. And in through it came a group of men sprawling over the floor on all fours. They were clothed in the skins of wolves. Immediately following these wolf-actors came men in upright position. These had blackened faces and were screened from view with salal brush. They were the hunters

hunting the wolves. A man carrying an ax headed these hunters. Time after time they chased the wolves around the central fire in the great hall. And each time some of the assembled populace joined the hunting group, all dancing a vigorous stamping dance; till every one in the large building was dancing. At this juncture the chief Klukwalle went and got the government officials and their guests and placed them at the head of the dancers just behind the hunter with the ax. Around the room once more they danced. Then there was a shriek and a hideous, ear-grating howl. And with one stroke with the death-dealing weapon the axman, in mimicry, killed the wolves, the representatives of the evil spirits that might mar the happiness of the village in the going and coming years.

Then there came a lull as the Shaker priest stood apart from the others as all repeated the doxology-prayer to Jesus-Man: "Kwax tsnahs mahah' stee stah nah' stee tah' tsohn tohs pray' kolh mahahs' stee stah'," followed by the repeating the Shaker ritual (translated)' "Do good to those who do good to you. . . . Our God is in heaven. If we die He will take our life to heaven. . . . Our Father who is there always have a good mine to us," this, in turn, being followed by a prayer-talk by one of the shamans to Kwattee, to the Mother Earth, and to their various other native dieties.

As soon, then, as all were seated, the "rich man's" performance was begun. And men wearing masks, said to represent the faces of the rich gods, began to dance behind a screen in front of the whale-sculptured totem pole in the rear of the building. In a few minutes the village chief came and stood in front of the screen. Soon a group of his aides gathered about him. Speeches of welcome were made by the chief and all who desired to do so, also talks explaining the purpose of keeping Christmas. Then the giving of presents followed. The teller, a man appointed for the purpose, called out in sonorous tones: "Chief ———— gives $25 to the old people of the village. And instantly a runner carried the glittering metal to the recipients. The teller called the name of another donor, and of another, stating the amount that each gave. And so on till all had given away all the ready money they had and also all the calicos and basket straw they had at hand; among Indians the richest man is the one who can give the most away, the government official in charge, his wife and her sisters receiving many baskets from the donors of that evening which, highly prized, they still have in their possession.

Then at the tap of the big drum beneath the east totem pole, eatables were passed around to all. And all helped themselves liberally; for what they could not eat they could carry home.

After the eating came the drinking of the coffee, a scene to be remembered. It was a race to see which side of the house, the men's or the women's, could drink their measured amount of coffee in the shortest space of time. And they drank hot coffee and drank it. And the coffee boys with their coffee boilers ran here, now there, to keep the coffee poured fast enough. The excitement ran high. A shout like the whizzing wind of a mighty storm proclaimed that the women had won. And the Christmas ceremonies of that year were over.

OBITUARY

DR. ALBERT B. REAGAN

SPECIAL PROFESSOR OF ANTHROPOLOGY, BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH.

In the death of Dr. Reagan, Northwest Scientific Association loses a good friend and an active member though we have never had the benefit of his actual attendance at our meetings, and to Science the loss is of an active worker in the Anthropology of the Indians of the Northwest. In NORTHWEST SCIENCE, his posthumous article on "Christmas Ceremonies at Quileute, LaPush, Washington, in 1906," in the current issue, records present day customs. In the issue of May, 1935, will be found an article from his pen on "An Ancient Culture of the Provo Salt Lake Region." This may be of particular importance to those interested in deciphering or making studies of the pictographs in the canyons of Idaho and Washington.

Albert B. Reagan was born at Maxwell, Iowa, January 22, 1871; died at Provo, Utah, May 30, 1936. He was married on June 15, 1903, to Ottilla Adelaide Reese, who survives him. His education was in public schools and Central Teachers College of Oklahoma; Valparaiso University; Indiana University (A. B., M. A. '03); Stanford, Phd., '25. He was a member and fellow of the A. A. A. S., and a fellow of the Ethnological Society; member of the Anthropological Association and numerous state academies of Science. His publications have appeared in many journals of the fields which interested him. Principal of Cornfields, Indian School; member of the U. S. Indian Field Service since 1899, he has served in many capacities. A special staff correspondent of the Deseret News, he has also contributed literally hundreds of articles to various newspapers, chiefly concerning the American Indian. He came to the faculty of the Brigham Young University in 1934, which he served until his death.

Public Health Phases of Nutrition*

By E. NEIGE TODHUNTER
Washington State College, Pullman, Washington

In the early days of Public Health service the chief concern was with the study and development of adequate defenses against infectious diseases. Later, there came a definite interest in food but it was a consideration of the ways in which food might injure health and with no attention to the great value of certain foods as a vital factor in promoting the positive health of the population. Food was suspected as a source of infection: it might carry pathogenic micro-organisms due to careless or unclean handling; it was considered as a possible health hazard because it might contain harmful substances added as preservatives, as artificial colorings, or as adulterants; or it might be injurious to health because of poisonous substances formed during deterioration of the food. The pure food problem was long debated and the interest aroused in the stormy discussions on the subject finally resulted in the passage of the federal food law close on thirty years ago. With adequate food protection assured by this law, the center of attention "has shifted from sanitation to nutrition."

Today, I believe that we can safely say that the public health program definitely recognizes its responsibility, not only to protect the population against disease and sources of infection, but to work constructively for the maximum physical well-being of the people and it is in this phase of public health that the science of nutrition has contributed outstandingly.

Alexis Carrell[2] states that "man is first of all a nutritive process" and that "nutrition is synonymous with existence." Such statements clearly show the fundamental importance of food and nutrition in physical well-being. Up until thirty years ago the idea was generally accepted that so long as a person had enough to eat that was all that was necessary. We now recognize that a person may have an abundant amount of food yet literally starve to death if certain essential food elements are not included in his diet. Quality as well as quantity of food must be considered.

J. B. Orr[5] says that "The rapid advance in the science of nutrition in recent years has shown that the influence of diet on health and physique is profound. It has been proved that much of the ill health which afflicts human populations can be attributed directly to deficiencies in diet and there is a certain amount of evidence indicating that increased susceptibility to certain infectious diseases, such as tuberculosis, and other pulmonary and intestinal disorders in young children may also arise from faulty diet."

Through the discovery of the vitamins and through increased knowledge of the importance of the mineral constituents in the diet we have learned that many diseases are directly due to dietary deficiencies. To enumerate some of these:

1. Rickets was for years the dread disease of childhood. It has been greatly reduced in incidence (though not yet completely wiped out) through the inclusion in infant diets of vitamin D along with an adequate supply of calcium and phosphorus.

2. Beri beri, not known in this country, but prevalent in Oriental countries, Brazil, Venezuela, Panama, West Indies and Labrador, is responsible for thousands of deaths of men, women, and children where polished rice and highly milled cereals form the bulk of the diet and are used in place of unpolished rice which carries the essential protective substance known as vitamin B.

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* Read Before the Bacteriology-Public Health Section of Northwest Scientific Association, 13th Annual Meetnig, December 29, 1936, at Spokane.

3. Pellagra is a disease responsible for many deaths in Roumania, Yugoslavia, South Russia Turkestan, Egypt, and southern states of the United States of America. Pellagra can be prevented by the inclusion in the diet of lean meat, milk, and fresh vegetables.

4. Xerophthalmia is rarely observed in severe form in this country but is common in some tropical and Eastern countries and was frequently observed during the war in those European countries where the population was deprived of animal fats. This disease is preventable by the inclusion of vitamin A rich foods in the diet. Recently there has been considerable discussion as to whether children in this country are receiving insufficient amounts of vitamin A containing foods and therefore suffer from decreased resistance to respiratory and skin infections and cansequent ill health.

5. Scurvy, which was responsible for the death of many sailors in olden times, can now be entirely prevented by the inclusion of fresh fruits and vegetables in the diet. However, infantile scurvy has been reported to have increased in some parts of this country during the depression due to inability of families on lowered incomes to provide fruit juice as a source of the necessary vitamin C.

6. Some types of anemia have been shown to be cured by the use of foods which are rich in available iron and which also supply some copper.

7. Dental caries is found everywhere, and though its cause and the means of its prevention are by no means so clearly defined as in the health problems just enumerated, yet there is a growing awareness that there is a close relationship between dental caries and dietary deficiency. There is convincing evidence that tooth structure and decay is influenced by the amount of vitamin C, of vitamin D and of calcium and phosphorus in the diet.

However, although nutritional factors can cure certain deficiency diseases, the applications of nutrition are in the field of public health rather than of medicine, since in nutrition and in public health we are more concerned with the prevention of disease than with the curative or medical treatment.

The advance in our knowledge of nutrition has been rapid and striking. Less than fifty years ago, nutrition as a subject was not considered of sufficient importance to be worthy of a laboratory for research, or even to be taught as such. Today, practically every university and college has on its staff one or more trained investigators with a well-equipped laboratory for at least some phase of nutrition research. There are also the government laboratories in Washington, D. C., the State Experiment Stations, as well as research centers in privately endowed institutions, and those supported by the manufacturers of pharmaceutical products and the food industries. From these laboratories trained nutrition research workers are filling the research journals with their findings, many of which have applications to public health.

The discussion up to this point has stressed what has been accomplished in the correction and prevention of deficiency diseases through the increased use of foods which supply the essential vitamins and minerals. The newer knowledge of nutrition goes beyond the point so far discussed, that is, beyond the corrective phase and is now concerned with the raising of average health to optimum health.

That this is readily possible has been demonstrated by numerous experiments on animals and on human subjects. To illustrate with just one example: Dr. Corry Mann[4] in England was interested to see if by making changes in a diet already considered adequate he could make any measurable health improvement. He worked in a school of boys grouped in cottages and thus living where diet could be carefully controlled. One group of boys remained for the experimental period of three years on the regular diet, other

groups received additions of sugar or fat or greens or milk to the diet. All the groups receiving additional foodstuffs made greater yearly gains in height and weight than the control group but the gain in both height and weight made by those receiving an additional pint of milk averaged per year twice as much as the gains of the control group who remained on the original and supposedly adequate diet. The milk-fed group of boys also showed noticeable improvement in general health and spirit.

This newer knowledge of nutrition involves several different aspects of the problem, namely: (1) research to determine the nutritional factors involved, and the quantitative requirements of various age groups for these nutritional essentials, (2) education to make available this research knowledge and to teach the public which foods are necessary for different ages. The breadth and difficulties of this phase of the work are immediately recognized when one realizes that such a program of education involves in many cases the changing of old established food customs and racial habits. However, this problem lies outside the present discussion as does the (3) economic phase. We cannot overlook the fact that a large portion of the population are not in a position to purchase the kinds of foods which would give them health protection.

Time will permit here only a brief reference to the research aspect of the problem.

The public has been made over-conscious of vitamins, partly through commercial advertising and because of the recent and spectacular nature of their discovery. Nevertheless, the nutritional problem of vitamins is important because modern methods of food preparation tend to remove or destroy them. Research studies are therefore concerned with: (1) such questions as how to prevent vitamin destruction in foods; which are the best food sources of the vitamins; how the vitamin values of foods may be increased by natural means, (2) the daily quantitative requirements of children and adults for the different vitamins.

The nutrition research program of the College of Home Economics at the State College of Washington includes both these types of investigation.

The vitamin values of food products of this state are being investigated, and particularly the fruits and vegetables with regard to their vitamins A and C content and factors which influence this. [1 6 7]

Extensive studies continued for several years on apples show that variety is the factor causing greatest differences in vitamin C content; the Winesap apple is almost three times as rich in vitamin C as the Delicious, Richard or Jonathan varieties, and the Rome Beauty, Spitzenberg, Yellow Newton and Golden Delicious are quite similar to the Winesap. We have found that a Golden Delicious apple with the peel removed supplies only half as much vitamin C as the unpared apple. Storage conditions have been found to influence the vitamin C content, storage at 45 degrees F. causing a loss of one-fourth the original vitamin C in a period of six months but with no measurable loss over the same period of time when kept in cold storage at 32 degrees F. In our laboratory cooking has been found to reduce the vitamin C content of Jonathans by more than one half (unpublished data).

Investigations on local apples show that they compare favorably with oranges and similar fruits as a source of vitamin A and that there is a higher concentration of this vitamin in the peel than in the flesh of the apple.

We are also investigating the vitamin values of frozen berries and with red raspberries have found the variety to be an influencing factor. Marlboroughs were found to contain twice as much vitamin C as Cuthberts, and other varieties are now being tested. Frozen red raspberries may be considered as one of the very good sources of vitamin C being similar in this respect to tomato juice. Thawing and

leaving to stand at room temperature was found to cause a destruction of more than half of the original vitamin C content.

Such laboratory findings are illustrative of the necessity of educating both the producers and the public in the selection and handling of food materials in order that the greatest health value may be obtained from them.

The second problem mentioned earlier, that of determining the actual quantitative requirement at different ages for various vitamins, is also being studied in our laboratories by Miss Post. The present investigation concerns the quantitative requirement for vitamin C. The test depends on the fact that the amount of vitamin C excreted daily in the urine depends on the past intake.[3] Measurements are made by a chemical titration with the redox dye, 2;6 dichlorophenol indophenol under specified conditions. We are at present attempting to determine the average range in daily excretion of vitamin C in the urine of normal adult women; and also to determine their response to a large dose of the vitamin. If a person has been receiving an adequate amount of vitamin C in the daily diet, then when a massive dose is given there will be a rise in the urinary excretion almost immediately. But a subject who has been receiving an inadequate dietary supply of this vitamin will require several days before the body is "saturated" enough to permit an increased urinary excretion.

Findings from seven normal individuals so far studied indicate a wide range in daily excretion of vitamin C and an apparent relation to dietary intake; two subjects consuming diets low in fruits and vegetables excreted ten to fourteen mg. vitamin C respectively; three subjects on diets including an average amount of fruit juice and salads, excreted 30, 36, and 24 mg. daily, while two individuals whose diet included considerable quantities of fresh fruits and vegetables excreted 60 and 83 mg. daily. Saturation tests to determine the amounts normally required by these subjects are now in progress.

CONCLUSION

Through dietary studies, animal experimentation, and research in the biochemical laboratory we have learned which foods, because of their richness in minerals and vitamins will cure the deficiency diseases which were once so prevalent. A more recent contribution to public health has been made through nutrition research studies which have shown that a so-called 'adequate' diet can be still further improved. Simply by shifting the proportions in which certain of our everyday foods are consumed and giving greater dietary emphasis to milk, fruits and vegetables, there has been made possible a greater reduction in early death rate, a greater expectation of life in the adult.

Present problems in the State College nutrition laboratory are contributing to the knowledge of the factors influencing vitamin content of foods and to the determination of quantitative requirements for vitamin C.

Not only the public health but the efficiency, security and happiness of our people will be ensured when the current findings in nutrition research become so widely applied that all will reach such "a state of well being that no improvement can be effected by a change in diet."

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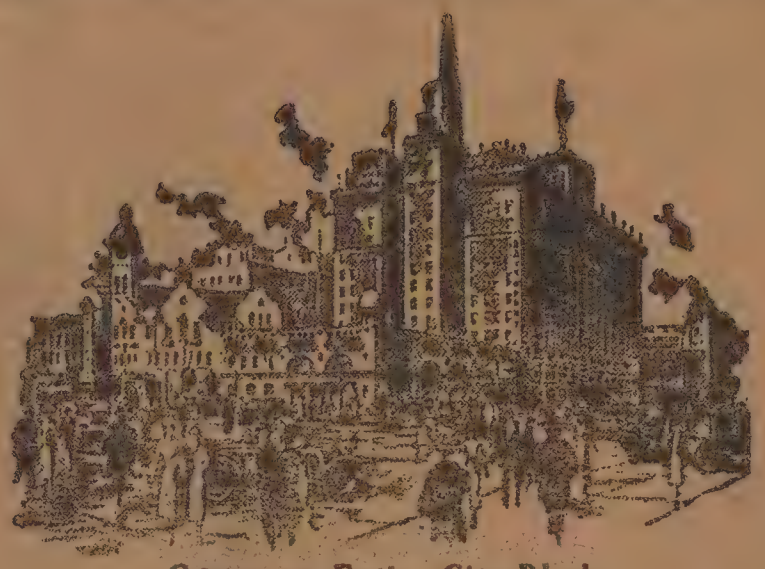

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"Soil and Water Mean Food and Drink"

By W. A. ROCKIE

Address of the Retiring President of Northwest Scientific Association, at the "annual dinner," Davenport Hotel, Spokane, Washington, December 29, 1936

In 1908, Professor T. C. Chamberlin, physiographer of the University of Chicago, addressed the Conference of Governors of the United States on the subject of "Soil Wastage." He said, "The assured future habitability of the earth requires the present consideration of conservation of the basic resource—soil. The fundamental problem is that of preventing water falling on the surface from running off as erosive surface floods."

The manner in which we have handled water and soil since this warning was given in 1908 causes one to wonder whether we have recognized their worth. Do we appreciate what water and soil mean to us? Do we realize the degree to which both are necesasry in supplying our drink and food and that the sudden withdrawal of either one would be a disaster to any community? Such deprivation, long continued, could have but one effect—starvation with all its attendant tragedy.

Although my personal experiences do not include starvation, they do include severe hunger and severe thirst. Such experiences are mentioned merely to emphasize my conviction regarding our dependence upon soil and water. This dependence inseparably ties the two together.

When one has had nothing but boiled, unsalted and unflavored navy beans for several days, he is hungry—though in a limited sense. When one has not tasted fruit or vegetables of any kind for months, he is starving in that same limited sense. But when one has been tramping across an uninhabited, unwatered plateau for two days without food or water, and he is scared and panicky as well, he is really both hungry and thirsty. When one becomes sufficiently "dry" to flop down and drink dirty, stale, stinking water that has accumulated in the depressions left in the mud by the hoofs of cattle at a nearly dried up watering place, he is really thirsty.

I recall a high plateau in eastern Idaho along the western edge of Yellowstone National Park which was being surveyed. This plateau had no surface water supply of any sort. Transportation of supplies was difficult and possible only by packtrain. All water was brought some twenty miles in kegs on the backs of the pack animals. Drinking water for man and for pack animals, water for washing and bathing, dishwater and water for laundry, all had to be hauled in. To begin with, the kegs in which the water was hauled, and from which it was always very stingily drawn, retained the characteristic flavor of a nationally known soft drink. That flavor or odor was in our drinks, it was cooked into our foods, it flavored our bath water, and was boiled into our clothes. Although that camp existed more than twenty-five years ago, I still loathe the taste of the famous beverage. In that camp, we learned to take only the minimum amount of water needed, whatever the purpose. Even the pack-animals were short-rationed at the dry camp so that they would gorge themselves with water at the source of supply, and they really became good camels. We drank sparingly; we washed our hands and faces sparingly; we washed the dishes from which we ate and the clothes we wore, always using water stingily. On that plateau we came to appreciate the degree to which the routine of our daily lives is built around the availability and use of water.

Contrast our life here today—our modern water systems with hot and cold water for drinking, bathing, and sanitary

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purposes at all times, frozen ice cubes to make the drinks more refreshing, water for machines to launder clothing, and to wash table and cooking ware, water in the car radiator to keep it operating efficiently, water power to run all of the electrical appliances in the home and to furnish us light, and innumerable other direct and related uses.

If you do not believe in the absolute necessity of water in all these uses; for instance, in the car radiator, try draining the radiator dry in the middle of a waterless, totally uninhabited and seldom traveled desert that stretches fifty of more miles in every direction, and enjoy the fun of getting the car to water or water to the car. It's a job either way. I did that once, though not by my own choice. I was lost on the desert at night, the temperature was approximately zero Fahrenheit, I could improvise no container into which to drain and save the water, the gasoline supply was too low to run the engine through the night hours to keep the radiator warm, and there were no wraps to put over the engine and radiator to protect them. I did only what anyone would have done—tried to protect the radiator. The importance of water was peculiarly impressed upon me by the results of that experience. It required twenty-four foodless and drinkless hours to get the car to water. I have another vivid recollection of this same desert. It had been widely advertised in 1907 as the Palouse Region of Oregon. At that time the lands were said to be fertile and to produce abundantly. In my boyhood home in Nebraska, I was hired to nail up flaming posters advertising this wonderful land. Great changes occurred between the days when I nailed up those posters and the night when I was lost in the middle of that man-made desolate waste.

Many of my boyhood activities in eastern Nebraska centered around Rawhide Creek, which flowed eastward through the north edge of the Platte River Valley, roughly paralleling, but several miles distant from the river. This creek was THE stream of my boyhood days. The water was black at all times—silt-laden even then. Nevertheless, it meant much to myself and my friends. We fished in it, swam in it, skated on it, boated on it, explored it in our homemade canoes; in fact, we learned every hole, crook and other peculiarity of the creek for many miles both downstream and upstream.

One day in my eighth summer, I was permitted to go fishing in Rawhide Creek, but was unable to find a fishing partner. Finally, in desperation, I picked up a little six-year-old in preference to going alone. Arrived at the creek, we found that recent high water had left the banks all slippery with newly-deposited mud. It covered everything. In imitation of my elders who fished in the Platte River, I had made a small trot line. Trot lines have several leaders attached at intervals to the main line which is stretched taut by the combined effects of the stake on the bank at one end, an iron weight tied to the end that is thrown into or across the stream, and the force of the current which takes up any slack in the line. The arrangement I made with the unwelcome but invited partner—namely, that of helping me bait the three hooks with angle-worms in return for half of the fish we caught, indicates that I was not overly confident of the fish that might be caught.

The place selected to set the line was in heavy shade, the creek did not exceed eight feet in width, and immediately after setting it we went to the swimming hole where we mud-crawled our way around in eighteen to thirty inches of muddy water. There we stayed until almost dark, finally to don our few garments and skip back to reclaim our fishing line. We usually caught bullheads from six to twelve inches in length, but we found on reaching

our line that a hook was caught on a submerged snag. As I waded in to recover the caught hook, the snag suddenly came to life. I escaped to the bank, put the line over my shoulder with my back to the creek and ran up the bank. Behind me, in that gooey, slippery, slimy mud, tumbled and flopped a blue channel catfish such as that caught by the big folks in the Platte. It really looked like a whale to me. I was happy as a lark and was ready to start home with the catch when this little shrimp of a six-year-old reminded me that half of the fish was his. Things looked bad indeed, and darkness was coming soon. I tried unsuccessfully to trade him my fishline for his share. Then I tried my knife and other possessions that are found in a boy's pockets, but he was not interested. As a final climax, I offered him all the money I had at home—five pennies to be exact—and he accepted on condition that I get them before I took the fish home. I scampered home and back so that I could shoulder MY catfish. It proved to weigh eight pounds. My chief regret was that it was practically dark, and my march of triumph homeward had neither spectators nor applause.

Rawhide Creek yielded many messes of fish and many good times in the ten or more years that I skated, waded, fished, boated, and swam it. Until last year I always remembered it as it was in those times. Yes, the swale is there, but there is no water, no stream. It is absolutely dry except when in flood. The progress of erosion has made an all too tragic end of happy memories.

Another stream, Beaver River, which flows through central Nebraska, left a very vivid impression on my boyhood recollections. During the summer following my fourth birthday my parents drove by covered wagon to their old homestead near this stream. During that trip my elders went boating and fishing many times on the Beaver River. Because of my tender years, I merely watched the older people. In my teens, I again made the same trip by covered wagon, this time as driver for my mother and sister. On this journey, I swam, boated, and fished for several weeks in the stream. On this second occasion the stream varied from thirty to sixty feet in width and was generally too deep for me to wade across. There were dams that create power for flour mills at the towns of Albion and St. Edwards, with really wide and deep pools below the dams. During the whole summer, I fished, boated, dived and swam with the boys of those communities. The bass fishing was great—big ones and lots of them. The pools were deep enough so that when we dived from the top of the twelve or fifteen-foot dam into the pool below, we had a hard time reaching the bottom. These pools were wide enough so that it was a good swim from one bank to the other, probably between sixty and one hundred feet.

That was a wonderful summer for me. Last year, when I first saw Beaver River again, the width of the flowing stream in few places exceeded one to two feet, and its depth was only an inch or so. They told me that it even goes dry now, flowing only for a few days after heavy washing rains. The old dams are still there, but the mills are not run by the power of the stream flow. There is no pond held back by the dam, and there is no pool below it. The old millpond and the channel are absolutely filled with silt. It is a tragic change.

The day after my return to Beaver River, it rained—two or three inches in a little while. Then I saw Beaver River in action. It was bankful with muddy water which, as Mary Roberts Rinehart so aptly said of another stream under similar conditions, "was too thick to drink, but too thin to plow." It became living, active, and noisy instead of harmless, passive, and quiet. It overflowed its banks; it washed away the land. It trapped animals and people, and destroyed

the growing crops. It undermined bridges, and it submerged buildings. Then the stream went down almost as quickly as it had risen and a few days later was again but a mere trickle. Beaver River has changed greatly since the days of my boyhood.

Another summer during my teens, I spent at Canton, South Dakota. Canton is located along the Little Sioux River, which, at that time, was one hundred to one hundred and twenty-five feet wide and averaged six to ten feet deep in the channel. The summer was largely spent fishing for and catching pike. This river, too, afforded good fishing. I saw that river again recently. Another practically dry channel with fishing, boating, and recreation all completely destroyed.

These are but a few specific examples of streams that I have seen change. I, personally, know of many others. Something has happened to change these streams from a uniform year-around flow to wet-weather monsters that fail entirely in dry weather.

As a nation or as individual communities, we do not yet have sufficient data to enable us to state exactly the entire cause or causes of these changes that have occurred, but we have incontrovertible data which establish certain changes as contributing causes. The degree to which any of these contributing causes are responsible for the changes which have occurred, undoubtedly varies with different regions and sections. One factor may be important or dominant in some localities and of relatively minor or negligible importance in others.

There is positive evidence that the changes in our streams and the lessened water supply so vital to our activities are largely caused by changes that have been made by our present agriculture in the extent, type, permanency or periodicity, and density of plant cover on the land. Considerable areas of the drainages I have mentioned were still occupied by native grasses when I knew them best. Today these watersheds are almost entirely in cultivation. This removal of native vegetation is often a contributing cause. The breaking down of the physical structure of the soil to a more compact, less permeable aggregate is also a contributing cause. This change results from the chemical and the physical breaking up of the decayed and the undecayed organic matter which was originally contained in our soils and which held the soil particles together. This organic matter accumulated in our soil during the thousands of years that it was clothed in nature's protective plant cover. Under cultivation the soil is steadily becoming less flocculent and more puddled. It has less and less soil binder. It holds smaller and smaller portions of the precipitation. Floods and uneven stream flow tend to result.

Another partial cause which may be only locally applicable has resulted from our efforts during several generations past "to get rid of water" rather than "to retard water flow." As a result of a concerted program to speed up the disposal of water—and this was embodied in our past programs of so-called flood control, in drainage projects for making agricultural lands, in highway construction, and probably in other operations—we have in some cases, overdeveloped our surface drainage to a damaging degree. Our intentions in these programs have been of the best, but some of the results class with the worst from the point of view of soil and water conservation.

A series of droughty years has undoubtedly contributed directly to the drier conditions that exist generally, and has contributed indirectly to every one of the different changes that have resulted. But these droughty years have occurred only in certain portions of the country at any given time, while such changes as I have mentioned, and in a few instances described, have not been limited to the

drought-stricken regions in droughty years. The trend over the United States is general and progressive whereas the droughts are local and spasmodic.

The combined effects of these several factors in the rather extensive drought areas of recent years have become matters of prime regional and national importance.

Recently we have seen crop failures in several regions within the United States where we had not considered failures possible. In 1930, some of the best land in the entire Cotton Belt had a cropless year. In 1934, and again in 1936, agricultural land that represents the hub of American agriculture had wheat fields heading out within six inches of the ground and corn fields which failed to produce corn. Fields in which the tassels are usually eight feet from the ground had stalks less than two feet in total height. These cropless years would not have been so disastrous had no water been wasted during that time, but in these very drought areas more than enough water was wasted in floods during these years to have greatly decreased the seriousness of the conditions.

These conditions and results cause those who give them thought to inquire—where are we headed? By what route? And for what end? Are our objectives and our methods of attaining these objectives soundly based from the technical and practical points of view? The processes by which erosion and flood are made possible are well known.

In the virgin vegetated condition, lands in general absorbed practically all of the precipitation that nature bestowed on any given section. Only highly unusual combinations of conditions caused much surface run-off. With the removal of the protective mantle of plant growth from a large proportion of our land area, the most effective "overcoat" that the soil had was removed. With the "heavy" or "winter overcoat" gone, the old earth was left exposed and inadequately protected at some rather vulnerable spots. Her remaining protection consisted of only a fabricated or synthetic garment that was a combination of decayed vegetation and particles of earth itself. These vulnerable or tender spots have suffered serious damage because of the absence of the heavy "overcoat."

We have since proceeded, by means of continued and repeated tillage of these lands, to return to dust this second "robe." It has been pulverized again and again, to a progressively finer grain or texture, until it no longer has body enough left to hold together against the action of wind or water. Neither is it sufficiently sponge-like to absorb the precipitation as it once did. As a result of these changes, we are losing as flood run-off, water that would otherwise TEND to cause larger crop growth, higher humidity, lower maximum summer temperatures, higher water tables, more constant springs and streams, and lesser floods.

On most of our uncultivated areas, we have accomplished practically the same results, though generally in lesser degree. The original plant cover, on a large part of such lands, produces but a fraction of its former growth. Grazing land, which once supported heavy grass cover, now stands relatively bared of cover. Dense and luxuriant stands of bunchgrass in the Pacific Northwest have been practically killed by abuse and overuse. In their stead, we now have either vast expanses of the annual cheatgrass or of the relatively inedible sagebrush, or other relatively worthless plant species. Although these plants are better than no protection at all, they are, nevertheless, inadequate. This leaves the land only partially protected, similarly reduced in its production of food for live stock, and equally ineffective as a sponge for the retention of the priceless rains which fall. Forest lands, although still retaining a larger percentage of their original protected condition than do either the cultivated or range lands, do not remain thus

because of man's guiding hand. They stand so in spite of our destructive hand. We have done our worst to destroy our forest cover, but simply have not yet had adequate time to make a complete job of it. True, our national forests and certain state and private forests represent exceptions to this rule in our geographically limited efforts at forest protection.

Some cumulative undesirable tendencies are certain to follow the treatment that we have accorded our land. I want to refer to some specific changes on which I spent several seasons of study. The measurements to which I particularly refer were made in 1927, 1928, and 1929, in northern Idaho. Among other things, a direct comparison of the effects of (1) a forest cover and (2) a duff cover, on air and soil temperatures[1] was made.

I shall use the hottest day in 1928 as an example of direct comparisons. The maximum official temperature on July 26, 1928, was 108°F. at Spokane and Pullman, Washington. (Our thermometers had been checked for accuracy by the U. S. Weather Bureau at Spokane.) One placed in a kiosk, five feet above the ground in a forest clearing, registered 108°F. Under the shade of a forest cover, and under otherwise comparable conditions, another registered a maximum temperature of 87°F. The shade of the forest cover was therefore 21°F. more cooling than is a kiosk.

Another series of thermometers was placed on the soil surface. One, lying on the duff in full sunshine, recorded a temperature of 132°F. Another, with the mercury bulb entirely coated with lampblack, was placed in black ash on partly burned duff under full sunshine. It showed a temperature of 182.6°F., a difference of 50.6°, resulting from the combined heat absorption by the lampblack and the ash. It has been assumed that any black non-reflecting surface on similar ground surface in full sunlight attained a like temperature. A third thermometer, placed in the duff one inch below the point where 182.6°F. was registered on the blackened bulb, reached a maximum of 59°F.—a difference in soil temperature of 123.6°F. caused by the protection of one inch of duff. It thus becomes obvious, without presenting additional figures, that soil temperatures under forest and particularly under forest-protected duff will be materially lower than without such cover.

When these changes in soil temperature are known, it also becomes obvious why springs in the forested areas are cold regardless of whether their source is from a deep or a surface formation. The difference in temperatures also reveals why springs in non-forested regions are generally less cold.

This tendency toward higher temperatures on and in the land with the baring of the soil is a rather vicious one. If it is correct to assume that the baring of the land starts a tendency toward higher temperature, then it is correct to assume that higher temperatures bring higher evaporation losses, which in turn lower the water table more rapidly than would be the case otherwise.

Where is all this discussion leading? Is the matter worthy of discussion? Are we interested in air and soil temperatures, ground water supply, and plant growth as factors in maintaining the even flow of streams and in controlling erosion?

I have what I believe to be authoritative information that on parts of the Sahara where there are forty inches of rainfall annually, plants are utterly unable to get started because of the extremely high maximum temperatures of

[1] These temperatures were taken incidental to experimental ecological studies in the office of Blister Rust Control in the U. S. D. A. George L. Luke and G. W. Hammar, of the Physics Department of the University of Idaho, were employed under my direction to make these temperature records.

the soil. Is it possible that our own Northwest could reach such a combination of conditions with our present climate? What changes in soil and air temperatures, and ground water supply in the Northwest would react on plant growth sufficiently to put large areas in the desert class? How is our present use of the land encouraging such an end?

Here in the Pacific Northwest we have local areas where erosion conditions are comparable to those in the "Dust Bowl" of the Middle West and the parts of the Sahara desert I have described. The presence of these areas definitely indicates the ultimate condition of millions of acres if present practices are continued.

I believe we are agreed that our soil and water mean food and drink. We are fortunate in not having carried most of our lands as far "down the hill" toward the destruction of our food and drink as have some older sections of this country.

It is up to us whether we use or whether we lose this present advantage.

Photographic Recording of Thermal Transitions in Solids[1]

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For some time, in the laboratory of physical chemistry at the University of Idaho, we have been interested in accurately locating thermal transitions in crystalline solids in connection with our researches on molecular rotation in crystals and studies of the dehydration of hydrates.

A thermal transition is a phenomenon exhibited by substances wherein a definite quantity of thermal energy, i. e. heat, is absorbed or given up by the substance, depending on the direction in which we pass through the transition. Thermal transitions usually take place isothermally at a definite fixed temperature, however, some are known which take place over a small temperature range. They are a manifestation of inter-molecular or intra-molecular changes, or both, within the substance. Such thermal transitions in solids may arise from the following causes: 1. Change of state, as in melting; 2. Change from one polymorphic form to another, as the change from rhombic to monoclinic sulfur; 3. The inception of molecular rotation; and 4. Dehydration and similar thermal decomposition reactions. It is the latter two types that have been of interest to us recently.

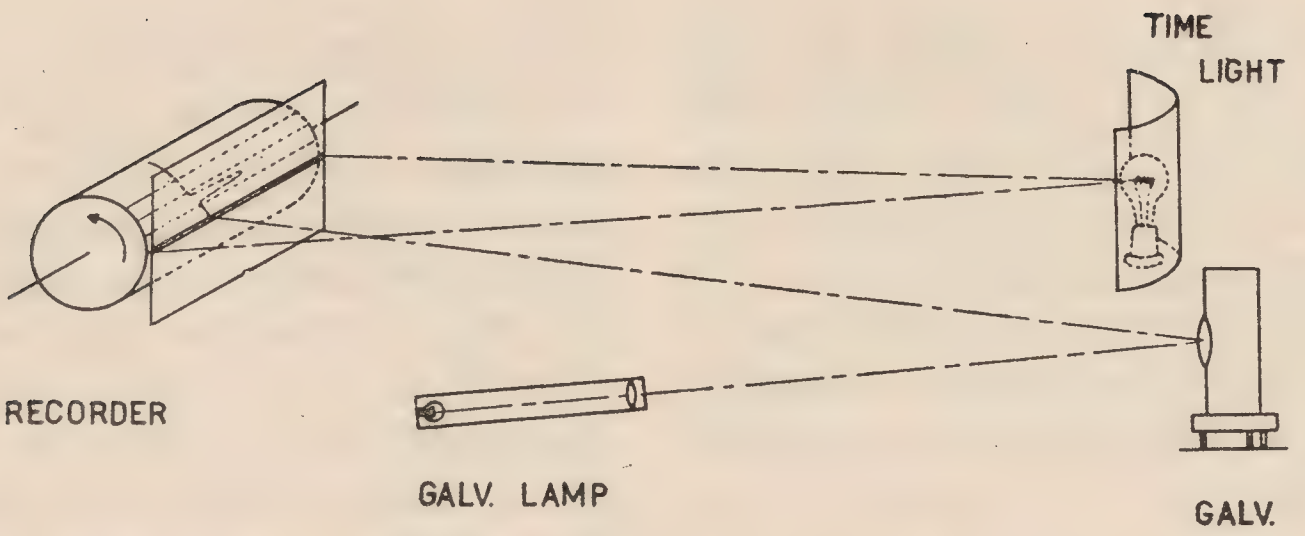
Molecular rotation in crystalline solids was discussed in detail in a paper[2] presented before the Chemistry-Physics Section of the Association at the 1935 meeting, Briefly; it has been demonstrated experimentally, and fully justified theoretically, that in certain crystals a continuous spin or rotation of molecules or atom groups may be expected to set in at some temperature below the melting point of the crystals. The criterion for such rotation is that the molecules or atom groups must possess a small moment of inertia. The inception of rotation will be accompanied by the absorption of energy, thus giving rise to a thermal transition in the substance. For example, methane molecules would have a small moment of inertia, and in solid methane rotation has been observed to set in at -252.7°C., the melting point of methane being -184.1°C. Similarly, the ammonium ion is another atom group with a small moment of inertia, and transitions involving the rotation of the ammonium ion have been found in several ammonium salts. In ammonium iodide such a transition occurs at approximately -42°C. Other molecules and atom groups which meet the requirement of a sufficiently small moment of inertia to be

expected to rotate in crystals are NH_3, H_2O, N_2, O_2, H_2, HCl, HBr, HI, H_2S, CH_3 groups, and CO_3^{--}, NO_3^-, and CN^- ions. It seemed to us that this phenomenon deserved a systematic investigation, so we are at present studying three types of compounds which are expected to show it; namely, ammonium compounds, hydrates, and cyanides.

We are also making further studies of hydrates for the purpose of determining, if possible, the mechanism by which they dehydrate when heated. It is well known that many hydrates dehydrate stepwise, forming a series of hydrates, finally ending up with the anhydrous salt. There are numerous cases where the exact composition, and even the existence, of some of these hydrates is doubtful. A famous case of this kind is that of the so-called calcium sulfate hemihydrate, $CaSO_4.1/2H_2O$, commonly known as Plaster of Paris. The controversy over the composition and true nature of this substance is more than one hundred years old. The finest piece of work yet done on it is that of Weiser and his co-workers[3]. We hope soon to report results by a different method substantiating those of Weiser. In collaboration with Mr. Ivan Taylor[4], we recently reported the finding of the hitherto unobserved tetrahydrate of copper sulfate. These studies of well-known hydrates will serve to show the fertile field for thermal studies of dehydration.

A simple temperature-time curve would locate these transitions provided the energy change is great enough. The energy change involved in many rotational transitions, however, is quite small. In the case of ammonium iodide it is only 69 calories per gram-ion. A more sensitive method is therefore necessary. We have been using a differential temperature method[5] in which the differential temperature between a neutral body and the sample being studied is obtained while warming or cooling the solids at a uniform rate. The differential temperatures are measured by the use of either single junction or triple junction copper-constantan differential thermocouples with one half in the neutral body and the other half in the sample. The couple is attached directly to a sensitive galvanometer and the temperature differences read as deflections on a scale at a distance of 90 cm., readings being taken every minute. A second thermocouple in the sample gives the temperature of the sample every minute to the nearest microvolt by means of a Leeds and Northrup type K potentiometer. A plot of the deflections of the differential thermocouple against time shows the location of any transition in the sample, and if temperatures of the sample are plotted against time on the same graph the temperature of the transition can be found immediately.

If one is to systematically study a large number of compounds, the above method will soon prove very tedious because of the many readings required. A still more serious matter is to get an accurate shape of the curve as it passes through the transition. This arises from the rapidity with which the galvanometer deflection is changing at this point and the consequent difficulty of taking sufficient readings to locate the curve with accuracy. Photographic recording of these deflections continuously during the experiment would give an accuracy hard to attain by the visual method. By means of the generous research grant received from the Northwest Scientific Association a year ago we have been able to construct such a recording device. No claim is made that the device embodies any new principle in the photographic recording of data. The fact that it has proved to be exceedingly satisfactory for the purpose for which I designed, and the possibility that others with similar problems may find it useful, would seem to warrant a brief description of it.



The recording device consists of the following four parts (Fig. 1): the recorder mechanism, galvanometer, galvanometer lamp, and a light for exposing time lines on the photographic paper. To protect them from vibration the parts are mounted on a heavy board which is tightly screwed down to form the lid of a heavy box 48″x18″x12″ filled with 500-600 pounds of sand. The box of sand in turn is mounted on a two-inch layer of cork and four layers of felt such as used for rug pads in the home. The heavy box of sand by means of its inertia damps out any vibrations of the building which might be transmitted through the cork and felt. It has the advantage over a concrete pier that it is somewhat easier to move in case the research is moved to another location. The recorder and sand box are placed in a light tight cupboard beneath the laboratory research table.

The recorder mechanism itself is essentially a rotating drum on which the photographic paper, Eastman P. M. C. Bromide No. 2 Contrast, is attached. The drum was made by setting duraluminum end pieces into a 7.5-inch length of brass pump cylinder and turning it to a true right cylinder on a lathe. The finished diameter is approximately 5.25 inches, making the circumference 16.5 inches. The paper is held in place by strips of springy steel which slide into slots attached to the ends of the drum. Arrangements are made to accommodate sheets of three different lengths; 16½, 8¼, and 5½ inches. The drum is fastened to a ½-inch steel shaft which turns in brass bearings. The shaft is attached, by means of a self-aligning joint with a set screw, directly to an IM2 Telechron Chart Movement which rotates the drum in a counter-clockwise direction giving one complete rotation in two hours. The rotating drum is mounted in a case directly in front of a horizontal slit with an opening of 20/1000 of an inch. The slit is provided with a shutter which can be opened or closed from outside the cupboard by means of a string. A light tight lid protects the photographic paper from all light except that passing through the slit. The entire recorder with rotating mechanism weighs only 17 pounds and is easily carried from the laboratory into the darkroom for loading and developing.

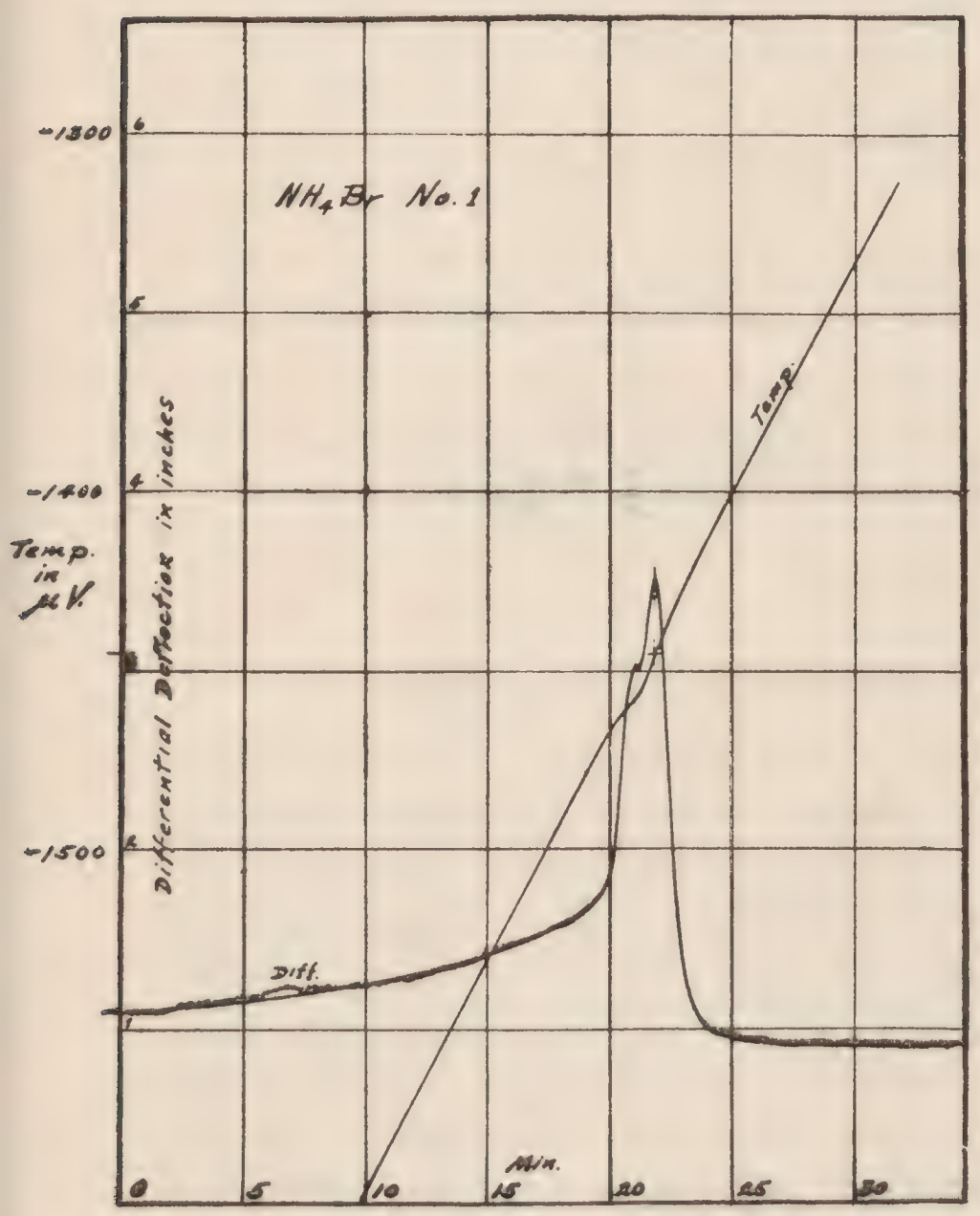
The galvanometer used is a Leeds and Northrup type R-2500 C instrument with a sensitivity of 0.159 microvolts per mm. under our conditions. Thus in the vicinity of 0°C. a deflection of 2.4 cm. (slightly less than 1 in.) on the photographs represents a temperature difference of 0.1 degree between the two junctions of the differential thermocouple. In case of the three junction differential the deflection is three times as great for the same temperature difference.

The galvanometer lamp is our own design, and is of the type which focuses a single vertical glowing filament as a sharp bright line. It consists of two cylindrical tubes the smaller of which slides smoothly in the other. In the outer end of the smaller tube is mounted a double convex lens of

20 cm. focal length. In the opposite end of the larger tube is the single filament lamp bulb in a miniature porcelain socket mounted on a spring brass holder which is held in the end of the tube by friction. Ample ventilation is provided around the base of the socket, and a shield prevents any light escaping in a direction that would fog the photographic paper in the recorder. The lamp can be conveniently clamped in position with the ordinary universal clamp found in all laboratories.

The lamp for exposing time lines on the photographic paper is a 40-watt bulb with a key in the circuit. An exposure of one second gives a line of just about the desired intensity.

The photographs are developed, fixed, and washed according to the directions accompanying the photographic paper. When thoroughly dry they may be fastened to a drawing board and the data



from the temperature thermocouple plotted on the same time scale. We then have a complete record of the transition. Fig. 2 for NH_4Br is a typical example of one of these records.

A discussion of the significance of our results in relation to the fields of molecular rotation and of dehydration of hydrates cannot be undertaken at this time. However, a few of the results can be given and their reproducibility and accuracy discussed.

In our investigation of ammonium compounds we have made preliminary studies of 22 compounds over the temperature range, -70° to +40°C. At the present time several of these have had a further detailed study. Among them are ammonium chloride, bromide, iodide, and sulfate which had been studied by other methods by earlier workers. We felt it advisable to repeat their studies with our set-up as a check on our method, and to obtain more accurate values for the transition temperatures in one or two cases.

The NH_4Cl transition has had the most study in the past, while those of NH_4I and $(NH_4)_2SO_4$ have each been determined by only one previous investigator. Our results for these compounds are listed in Table I. Except in the case of NH_4Br, a part of the determinations were of the earlier visual type. As an indication of the reproducibility of transition curves photographically recorded we can point to the three determinations for NH_4Br. Two of these were warmed up at the rate of about ⅓ of a degree per minute and gave curves as nearly identical as could be expected for separate determinations. The third was warmed up slightly faster, about ½ degree per minute, and showed a greater deflection at the maximum. The transition temperatures, i. e. the temperatures of the maxima, for the three determinations fall within a range of less than three microvolts.

TABLE 1

THERMAL TRANSITIONS IN AMMONIUM COMPOUNDS

Compound	Number of Determinations	Transition Temperature	Previous Value[6]
NH_4Cl	9	-30.55 ± 0.10°C	-30.4°C
NH_4Br	3	-38.20 ± 0.10°C	-38.0°C
NH_4I	6	-41.65 ± 0.20°C	-42.5°C
$(NH_4)_2SO_4$	5	-49.70 ± 0.20°C	-50.7°C

All curves for ammonium bromide show the inflection on the left side just below the maximum (Fig. 2). The recording of such fine structure shows the very decided advantage of photographic recording over visual methods, as such detail would have been extremely difficult, if not impossible, to detect visually. This inflection has not been reported before, and its significance is not quite clear. It has been suggested by other workers[7] that possibly molecular rotation sets in first about one directional axis in the crystal and then later about other axes. This seems to be the case for hydrogen bromide which shows three transitions at -184.1°, -160.1°, and -156.1°C. It is possible that this inflection, which is observed at -38.50±0.10° C. marks the inception of rotation of the NH_4^+ ion about one axis, and that the maximum at -38.20±0.10°C. marks the inception of rotation about all possible axes.

We wish to express our thanks and appreciation for the generous grant from the Northwest Scientific Association. It has very materially contributed to the success of this research, and it will continue to do so in our future studies. Thanks are also due Mr. Wayne Johnson for taking part of the measurements reported in this paper.

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[5] For details see reference 2.
[6] Crenshaw and Ritter, Z. physik. Chem. **B 16** 143 (1932).
[7] See Pauling, Phys. Rev. **36** 430-43 (1930).

TRAINING A FORESTER

Opening Statement

By H. T. Gisborne
Chairman, Forestry Section, Northwest Scientific Association

The program of six papers on "The Requirements and Training of a Forester" was selected for three reasons. First, to obtain western viewpoints and opinions; second, because of the marked recent change in both the popular and the professional conception of the term "forestry"; and third, because of the very significant increase in political interest in forestry during the past few years.

Previous discussions of the requirements and training of a forester seem to have been greatly influenced, if not dominated, by eastern foresters and forest educators. The present program was framed to permit developing western ideas and opinions by both foresters, forestry school faculty, and, in addition, the private practitioners of forestry. The names on our program speak for themselves; the attendance here today, including representatives of nearly all the major forestry schools west of the Rockies, and the large representation from the forestry profes-

sion, indicate an active western interest in our topic. As members of this Scientific Association, we have an opportunity to register our opinions as individuals. The Section has an opportunity to speak for the far-West.

There has been a marked change in the conception of the term "forestry" during the past few years, both in the East and the West. Twenty years ago, when most of us selected forestry as our life's work, and when we received our college training, the term "forestry" was restricted largely to the growing and harvesting of trees. Other forest benefits and uses, such as soil protection and streamflow regulation, were incidentally cited, but silviculture was THE THING. Later, forest grazing was included, especially in the West, and more recently wild life and the human recreational values of forest land and waters have been accepted as prime objectives of forestry. The economic field has been greatly broadened, and it is now recognized that sustained yield is merely one method of attaining a social objective.

It is worth noting in this connection that a sub-committee of the Social Science Research Council recognizes the social aspects of forestry when it states: "Social and economic objectives underlie the entire practice of forestry." And this committee indicates the new and broadened concept in its statement that "forestry is sufficiently important and sufficiently distinct from other phases of rural land use to justify separate consideration." In other words, forestry is now recognized as including several phases of rural land use in addition to the growing and harvesting of trees.

Probably the most outstanding development of the past few years which not only warrants but which demands the attention of the forestry profession is the social-economic-political movement illustrated by the CCC, the Shelterbelt, and the activities of the Tennessee Valley Authority, the Soil Conservation Service, and especially the U. S. Department of the Interior outside of its Park Service and Indian Bureau. When politics begins to take an appropriating interest the people of this country soon become vitally and personally interested.

At such times an unbiased scientific association such as ours, composed of well-informed members and not dominated by any particular group, should be able to contribute. Obviously one of the most promising and fruitful opportunities is in guiding the education of future foresters, because the educational process requires several years, and it must therefore anticipate future requirements if that is at all possible.

Technical Requirements for a Forester in the Federal Service

By ELERS KOCH

If I were inclined to be a stickler for exact definitions, I should start in by attempting to define the term "forester," and this meeting might spend the rest of the day trying to determine who is and who is not a forester.

For the purpose of our discussion it is not necessary to split hairs on definitions. I am going to talk about what kind of a man is needed as to personality, background, education, training and experience, to fill the general requirements for administrative and technical personnel in the Forest Service and other Federal establishments having similar functions in the management of forest land.

The fundamental sciences back of wild land management do not vary greatly, whether the land be managed chiefly for recreational purposes, for timber growing,

for forage production, or for water flow regulation. These major functions are in most cases so inextricably mingled that any system of management of wild land must generally consider them all, with due regard to specialization in the major ones on a particular tract.

It should be recognized from the start that all employees of the Forest Service are not foresters, and do not need to be foresters. Aside from the office force of clerks, accountants, draftsmen, etc., the Forest Service requires a goodly number of specialists in non-forestry lines—road engineers, bridge engineers, construction engineers, architects, landscape engineers, entomologists, pathologists, lawyers, editors, and the like.

In addition to these there is a large subprofessional force of the foreman type—construction foremen and superintendents, fire foremen, foremen of crews engaged in planting or timber cultural work, scalers, and the like. Most of these men have in the past been temporary employees, but there is now a movement to carry on the permanent rolls a larger percentage of this type of men, recognizing that they are not technical foresters or land managers, but a useful and necessary adjunct to forestry and land management.

Many of the arguments and differences of viewpoint relative to the requirements and training of foresters are due to failure to recognize this obvious fact, that the practice of forestry and the management of forest lands require a supplemental force of non-forestry technicians and subprofessional supervisory personnel to carry out the engineering and other works which are a means to the practice of forestry. Such supplemental professions and trades should be supplied by drawing men trained in those lines, rather than to expect forestry training to be broad enough to cover them all, from plumbing to bridge building.

The Forest Service has had so much engineering work to be done that I have even heard it proposed by a Forest Service man in an influential position that an engineering school training would be more valuable to the average Forest officer than forest school training. That is an expediency viewpoint that should be squashed. As valuable and essential as engineers are in their field, the background for a forest land management job must include much other than pure engineering.

I cannot emphasize this point too strongly, that there are several different kinds of jobs in Government forest work, some of which call for professional training in forestry, some for training in engineering and other technical professions, and some which do not require professional training at all. As a rule the best type of man for a foreman, who is actually leading and directing a group of men in a job of work on the ground, is not the college-trained man, but rather the type of man who has been brought up from boyhood in close contact with outdoor work, who knows from intimate experience the reactions of working men and who is at home with woods tools and machines.

This distinction is recognized in most lines of work. Any construction job, for instance, requires a technical force of engineers, architects and the like, who plan and generally direct the work, but equally important are the foremen who have learned their particular angle of the job from years of actual experience. The two jobs are not interchangeable.

Just so in the Forest Service. We need, in addition to the professional force, what may be called a subprofessional group who can act as fire foremen, foremen of construction crews, and also do under skilled direction some of the more distinctly forestry work, such as scaling, direction of slash disposal, and even much of the timber marking, planting and

stand improvement work, after the principles and specifications have been determined by forestry experts. This type of man should be definitely provided for in the permanent personnel, and classified under Civil Service procedure. Their jobs should have been learned through long experience and training on the job rather than by school training, and they would not ordinarily be eligible for appointment in the professional grades, although there are always among this class of men occasional outstanding individuals who, by special ability and self-education, may be able to pass into the upper grades. A rather rough comparison would be the noncommissioned and commissioned officers in the Army. The Forest Service in past years has been so ultra-democratic as to refuse to recognize this distinction in classification, but recognized it must be, with no disparagement of the fine men in the nonprofessional grade.

In times past the district ranger was often the type of man who belongs in the subprofessional grade, and his work was largely of that type. Generally speaking, this is no longer true. With the pioneer days about over, and conceptions of forest use expanding, the district ranger position has become an important one of land management. It is true that there are still many engineering jobs to do; roads, trails and bridges to construct and maintain, towers and buildings to construct, and telephone lines to put up. These things are only means to an end, and the district ranger's job becomes primarily one of managing, developing and using the resources produced in his district, the preparation of plans for timber use, grazing use, recreational use, game and fish management, fire control, and the administration of all these uses and activities. He is able to call in engineering specialists for technical jobs beyond his range, and he has a force of practical, skilled men under him to carry out his plans on the ground. It is distinctly the job for a technically trained forester.

Now, having disposed of the proposition that all employees on a forest management unit do not need to be technically trained foresters, let us get back to our major subject of the background and training of the forester. While there are many lines of specialization within the field recognized as forestry, there are two distinct lines which may require something different in the way of basic training and qualifications. The first of these is the administrative or land management line, which would include most of the rangers, Assistant Supervisors, Supervisors, some staff specialists, and the administrative force up through the Regional and Washington offices. The other is the research line. There has been, and I hope will contince to be, some interchange and transfer between these two lines, but I believe the young man in training for forestry would do well to make his choice between them and vary his basic training to fit.

At the present time it is practically impossible for a young man to get a foothold which will lead to the upper grades in the permanent National Forest administration without passing a technical Civil Service examination, which almost necessitates at least a four-year forest school course. This is as it should be; granted that there are in the Forest Service some extremely competent and valuable men who came up through the ranks and never saw the inside of a forest school—some of them nothing beyond high school, or even less. The old ranger and Supervisor examinations yielded some good men, who had only to demonstrate that they could ride, pack, chop, shoot, and run a compass line, but they also brought in a great many men who have been left behind in the march of progress. With a surplus of young men now knocking at our door, with both technical training and some practical experience, it seems hardly worth while to argue for modifying the entrance requirements in the

permanent forestry organization to include men lacking technical training. This, of course, does not preclude permanent employment of specialists in other lines, or men in subprofessional grades.

The forest school curriculum will be discussed by other speakers on this program. The field of forestry, including all wild land management, is so broad that there is practically no subject taught in the universities which would not add something to a forester's effectiveness and breadth of view. However, man's time on earth is short, and the best we can expect for the mill run of our candidates is that they will come out of school with the general aspect and point of view of an educated man, knowing how to read and to reason, and to expand the elements of scientific and technical knowledge obtained at school by use and study. We can expect that they will have a fair introduction to the natural sciences—the more the better. They will have enough engineering to make and read maps and make simple surveys, but we do not expect them to be fully trained engineers. They will, of course, have technical courses in silviculture, forest mensuration, forest management, range management, etc., as much as they can cram into a four or five-year course, and there will be many things they would like to get that they will have to leave out. A training in these technical courses is required to qualify a man as a forester, under any reasonable definition. He may have all the supporting sciences—botany, ecology, geology, zoology, entomology, chemistry, sociology and economics—but without a knowledge of silviculture, forest management and forest mensuration he is not a professional forester any more than a mathematician is an engineer.

The ideal collegiate training would be a six-year course in which technical forestry subjects, including engineering, appeared principally in the last two years, and four under-graduate years were devoted to a good general educational course with emphasis on natural sciences and mathematics, but with a good grounding in English, economics, history and similar subjects tending to broaden the student's viewpoint and give him the habit of thinking and reading in varied lines. This is of course the general scheme of such graduate forest schools as Yale. Men so educated should have a considerable advantage over the much narrower education possible in a four-year course. I believe the future trend will be in that direction.

After school, what? There are a lot of things the forest school graduate will eventually have to know that he will not learn in school. How is he going to learn how to put his theory in practice so that he can do or direct such jobs as cruising and appraising a block of timber, scaling logs, appraising and mapping the fire hazard types in a district, planning an adequate road system, making a timber or range management plan, or planning and organizing fire control on a protection unit, or even the more humble jobs of grinding an axe, hooking a chain on a log, connecting a telephone set, or packing a mule. A forest school graduate is no more a competent practicing forester than a medical student is a physician before he has had his experience as a hospital interne.

Practical experience under proper direction is the only answer. And here we have the phase of the young forester's training which has been the most neglected. Most of the forest schools have a reasonably standardized curriculum, which can perhaps be improved somewhat, but generally meets the requirements. Nothing but chance and the opportunity to get a job of some sort has governed the young man's field experience for the most part.

The Forest Service has been expanding and taking on new jobs so rapidly that, perhaps of necessity, its personnel policy has been a haphazard grab bag. It is to

be hoped that it is now getting sufficiently stabilized so that a more systematic policy of recruiting and training new men can be achieved. Any large unit of organization should know approximately the annual turnover of its personnel, and should plan to take on for training enough young men to fill the requirements. These men will naturally come from the junior forester and range examiner Civil Service lists. The procedure is liberal enough to allow a considerable degree of selection from these lists.

Aside from some specialist lines, the training of the majority of these men should be directed to lead to the district ranger position, the first permanent rung in the ladder of advancement in land management positions in the Forest Service, and through which practically all of our future foresters in management positions will go.

The young forest school graduate will in most cases have had at least two summers of field experience—usually whatever job he has been able to get. A wise personnel policy would lead to the sizing up of each man, determination of his past experience, and planned allocation to jobs which will round out his training. The experience to qualify for a district ranger's job would vary by Regions. In this Region, as an example, training should include timber survey or range survey work under expert supervision; timber sales work, including both marking and scaling; improvement work, which will teach the use and handling of tools and woods equipment; experience in fire control jobs, both as lookout and fireman; and, of course, as much fire fighting and other fire control work as can be gotten in It will not always be possible for every man to get assignments to every line of work, but if possible such special lines as planting, blister rust control, insect control, game patrol, recreational plans, etc., should be included. The training should be rounded out by assignment to a ranger district for at least six months as an assistant to the district ranger in all lines as the work occurs. The minimum time to qualify an average forest school graduate as a district ranger would be one full year plus two previous field seasons.

After service as a district ranger, future lines of promotion and assignment may vary with the capacity and trend of ability of the individual. Some men may stay permanently in the ranger grade. The usual line of advancement would be through Assistant Supervisor, Supervisor, and the various grades in the Regional and Washington offices. Specialists in various forestry and land management lines may be developed by special assignments and further study.

Where do range management men come into this picture? The answer is, that for service in the National Forests or other similar land management agencies, there is no place for foresters who know nothing of range management, or for range managers who know nothing of forestry. The basic scientific training for any job of wild land management is the same. Naturally, the men who are going up for the junior range examiner examination will specialize in range management subjects their last year or two in school, while the junior forester candidates will specialize in the more advanced technical forestry subjects. Field training on a management unit where grazing is important will naturally vary somewhat from that on a unit which is chiefly concerned with timber growing.

The same thing is more or less true of game management specialists. At the present time there are few men in this country specifically trained in game management, but, recognizing the fact that men in this line of work will have to learn most of their stuff on the job, I should be inclined to pick a man of technical forestry training and experience rather than a zoologist or biologist. The job of game management is only another phase

of land management, and the relation of the game to the growing crops on the land, forest and forage, is the most important phase of game management. Consequently, your game manager should first of all understand forestry and range management, with a supplemental knowledge of zoology. Certain specialists will be required for such branches as investigation in stomach parasites and other diseases of animals and similar technical lines, but these specialists do not have the best training for the broader phases of the job.

I have had in mind so far primarily the classes of men for employment in the Forest Service. The Indian Forest Department is, of course, a similar problem. But how about the National Park Service and the Soil Conservation Service—have they any use for technically trained foresters?

The Park Service is managing tracts of timbered land, many of them very similar to adjacent National Forests. Its object of management is different, and at present timber as a crop does not enter the picture, nor does grazing of domestic stock. Otherwise the problems are quite similar. The Park Service undoubtedly requires several different kinds of professional specialists, just as the Forest Service does, but it could use foresters to advantage, although a special course could be devised for National Park Service, which might include less forestry and more of some other sciences.

The Soil Conservation Service requires some foresters for true forestry work, since its field includes farm woodlot forestry. This service has employed some foresters on jobs not distinctively forestry; largely, I suppose, because more foresters have some knowledge of soil conservation work and of the related sciences, and the job is a new one lacking a specially trained force. Fundamentally, most of the Soil Conservation work is not forestry.

The discussion so far has pertained primarily to the class of men engaged in land management. There is also a very large class of foresters in Government service engaged in research, on many varied and specialized lines, some of which are pure forestry, others allied to forestry. Some of these fields are silviculture, forest products with its many ramifications, forest mensuration, forest protection, forest influences, forest entomology, forest pathology, forest economics, erosion, range management, wild life management, and recreational use. All of these subjects are further subdivided into many special lines. Most of them require a man grounded in the fundamentals of forestry, though some lines are so specialized as to call for primarily an engineer, a chemist, or a biologist. As I said before, I am not going to quarrel over just what is forestry or a forester. It is obvious that research in all these varied lines pertaining to forest management cannot be covered by a single line of education and training.

In times past a large percentage of the research personnel has been recruited from the junior forester list. It seems probable that this stage is passing and that in the future research personnel will have to have more advanced education in specialized lines up to a master's degree, or perhaps a Ph. D.

I have left to the last what is the most important phase of requirements for a forester, and that is the quality of the men themselves. At the risk of being classed as an oldtimer, who looks into the past and thinks nothing modern is as good as it used to be, I am going to venture the statement that the personal quality of the men who graduated from the forest schools in the first five or six years of the rise of forestry in the United States averaged considerably above the mill run of the present-day graduates. These men were drawn into the new profession by the magnetic influence of Pinchot, Graves, Fernow, Roth, and Schenck, and, in some way they tapped a higher stratum of American youth than the present-day for-

est schools are drawing from. This statement refers to averages, not to individuals. There are doubtless many men of the very highest type now in the forest schools.

Studies by Professor Graves and Guise in 1932 indicated that the intelligence tests of forestry students in most universities fall below the all-university median, and that in all cases the forestry median was lower in the scale than engineering, pre-medicine, pre-law, science, liberal arts, commerce, and chemistry. This is a situation that the forest schools could and should correct, by upholding entrance standards and jealously maintaining the dignity and character of the forestry profession.

I have sat in on many conferences for selection of a man for promotion to a vacancy in the Forest Service, and almost invariably the selection of the man hinged upon the personal qualifications and experience of the candidate rather than the quality of his technical training. The two essentials are intelligence and character. By intelligence I mean the quality of the brain, the ability to learn, to reason, and to use judgment. Character is a broad term, but the essential qualities are confidence, courage, and leadership. Since much of the work of a forester is in the field, it is essential that the forester possess a certain ruggedness of spirit and body which will enable him to meet with equanimity and to enjoy the discomforts and occasional hardships of woods life, and to demand the respect of the tough men of the woods he must command and associate with. This does not mean that he should be a "roughneck"; a man who "can chew tobacco and spit against the wind." We might remember that, of the intrepid men who attained the greatest height on the two most terrible mountains of the Himalayas, one was a poet and one a musician. A forester who attains the higher positions in the profession must combine the real ruggedness of the woodsman with the finer qualities and educated perceptions of a man who is at ease in the councils of the learned as well as in the logging camp. The selection, recruiting and subsequent training of such men are of far greater importance to the Federal Services than any possible modification in the forest school curriculum.

Outline of "The Requirements of a Forester by the Timber Growing and Logging Industry"

By C. L. BILLINGS

General Manager, Potlatch Forests, Inc.

1. I still believe that a forester in "the timber growing and logging industry" must be a person primarily concerned with the successful growing and harvesting of tree crops.

2. Such a person need not be a scientist as we know the term. It is questionable whether he need be a college trained man. It is still more questionable whether he need be a forest school man.

3. But he must be a man who knows how to think, knows how to figure and keep costs, knows how to display his ideas convincingly by both the written and the spoken word. More than all of these, he must have courage and vision. Vision to see the social and business opportunities in forest management and courage to plug for the realization of these opportunities.

4. Forestry is not an exact science. In my opinion it is not within a hundred years of needing to be exact. I am intolerant of the extremely weak attempts of the forest schools to treat forestry scientifically at the expense of their young graduates who need, instead of a smattering of this and that science, a good academic background and, very definitely, a good ground work in English, public speaking, cost accounting and bookkeeping, forest economics, political economy and sociology.

5. From these things successful foresters, in my opinion, can be made. If an individual shall also have had forest school training in Mensuration and Surveying, the elements of Management including methods of cutting, Utilization including required summer work in the woods, enough Dendrology and Silvics to enable him to identify species and know their habits and characteristics, his development may be hastened and his period of usefulness may have an earlier beginning. But these things are not essential.

6. A youngster heading into our woods to start his career in "the timber growing and logging industry" has one or all of these blazed trails open to him: Cruising, Scaling, Timber Marking for Selective Cutting, Engineering (helping to lay out roads, flumes, railroads, etc., and mapping), Camp Clerking and actual Logging (where he uses his hands and works as a laborer). When he has traveled all or most of these trails he will be well equipped to comprehend and enjoy the wonderfully exciting and interesting field of forest management.

"The Requirements for the Training of an Industrial Forester in the Lumber Industry"

By ERNEST E. HUBERT

Research Laboratory, Western Pine Association

To prescribe requirements essential to the training of prospective foresters planning to enter the lumber manufacturing field is an uncertain task at best and particularly so in view of the plastic state of this young profession. This unstable condition is no doubt affected by such factors as the rapidly changing economic picture and the gradual but very evident broadening of the field of forestry. These two factors, at least in our recent economic upheaval, seem to have developed in some degree simultaneously. The search for new fields in which men could be gainfully employed brought out the possibilities latent in forestry activities on the one hand; and, on the other, the serious need for controlling erosion and preventing floods focused attention upon the part the forester would be called upon to play in carrying out these huge federal and state projects.

That the field of forestry is no longer confined to growing and protecting forests but must include the production and utilization of the products derived from them has already been accepted. The rapidly forming picture of the forestry field as it is now envisioned by many, is a profession of great breadth, which not only considers trees in all their aspects, but also includes the rain drop from its origin in the cloud through stream, river and ocean back to cloud again. Vegetation other than trees must henceforth be given a prominent place; and fauna, soils, climate, geology and innumerable elements and factors must be considered in the new conception of this ever-broadening field.

Although moving slower and with less spectacular speed than other phases of forestry, the industrial side of the forestry profession has of recent years shown signs

of definite progress and expansion. One outstanding example of this progress is to be noted in the development of regional forest practice regulations which have been put into effect by the lumber industry and cooperating agencies of the Northwest with such encouraging results.

There is one particular branch of the broader forestry profession which has been more or less loosely recognized as covering the field of lumber manufacture. It has been somewhat of an orphan to the forestry profession more by non-recognition than by lack of parents and, though the fields of activity range from engineering to pathology, the work is confined mostly to research on wood and wood products. This side of the forestry profession has left the need for constructive development and only recently have economic conditions coupled with the recognition of benefits to be derived from fundamental studies on wood and its products given it a new impetus. Some of this backwardness may be due to the fact that the Forest Products Laboratory, designed to solve problems in wood products, and the Regional Offices of Forest Products, have been the only agencies other than private consulting chemical and engineering laboratories to which the lumbermen could turn for technical information.

Having readily available the agencies from which answers to his questions could be obtained, the lumberman made slow progress in past years toward the development in his own organization of research work on wood or in the employment of technically trained foresters in the lumber manufacturing industry. However, the picture has changed and the need for solutions of a number of urgent problems peculiar to a regional association of lumber manufacturers or to individual mills, and the fact that federal agencies were already crowded with projects had much to do with the turning of lumbermen to the active solution of their own problems. The experiences of all large industries point to a parallel course of development by the lumber industry resulting in the establishment of industrial research units and technical laboratory control of the products.

The trend may be seen in the development of distinct research units at certain western lumber mills in which from one to three wood chemists are engaged in the study of new wood products and in the improvement of the old. Another mill has taken up the development of a new wood preservative for the treatment of railway ties and similar products, and still another plant has set aside personnel and funds for the development of a new moisture meter for lumber. A line of new wood products such as insulating boards and sheets, fuel briquettes from pine mills waste and other items, has for the past few years been produced through the research agencies of a well-known group of progressive lumber manufacturers. The pulp and paper industry has long followed the practice of establishing technical control laboratories and of supporting research units. The association of pulp and paper mills supports an excellent research center at Neenah, Wisconsin, which has returned many times the funds invested in it. The Western Pine Association, a pioneer association in research activity for the lumber manufacturing industry, has maintained a steadily growing Research Laboratory since 1925. These examples indicate that the technical forester is rapidly taking his place in the lumber industry and that a new field is opening for young men with the proper ability and training who desire to select this branch of forestry as their life work.

THE SKILL DEMANDED

Young men planning to enter the field of industrial forestry and wishing to specialize in some phase of lumber manufacture must necessarily be equipped with the skill which such activities demand. This skill may be roughly divided under

two heads: manual skill and mental skill.

Of manual skill, an amount sufficient to meet the field, mill, and laboratory activities of the profession will be required of the young man seeking his life work in the field of industrial forestry. The ability to use dexterously the hand, limb and eye in carrying out the diversified activities of such a profession is a prime requirement. Even the laboratory worker if engaged on a research project must possess a versatility in manual skill which is above the average. He may be called upon to exert manual effort in a great many ways when working on special manufacturing problems such as occur in the seasoning processes or in the development of new products or the protection and improvement of the old.

While a certain high average of manual skill is required of an industrial forester the more essential skill requirement is that of mental equipment. The student preparing himself for such a field must not only master certain fundamental courses included as essential in all forestry curricula but he must in addition acquire, through education and experience, a background which gives him an understanding of the particular industrial field he plans to enter. If he selects to enter the field of wood chemistry, for example, in addition to a thorough training in the required chemistry subjects he must be equipped with knowledge of forest production and forest utilization and must have a fair, practical understanding of the manufacturing processes which are concerned with the product or products he expects to work with. His mental skill therefore will need to be of the highest type and the attainment of this skill can only be secured by a specialized program of educational training and some form of industrial training which will give the student a working knowledge of the processes of the industry and an understanding of the industrial viewpoint.

EDUCATIONAL TRAINING

The educational training of a young man seeking to prepare himself for professional work in the industrial forestry field must of necessity rest upon a number of well-grounded fundamental subjects. Whether he plans to become a research worker in the various wood producing and wood consuming industries or whether his aim is to become a technical worker, consultant, or executive in the manufacturing, distribution or sales activities; the underlying need for a thorough technical knowledge of tree growth and of wood structure, its properties and uses, cannot be denied. The fact that he is entering the industrial field lays stress upon the practical slant to his educational training but this should not be misinterpreted to mean that his college courses shall be overflowing with visits to operating mills and that he must be taught, manually, how to pile lumber or how to load a box car with wood products. Such necessary information he can acquire during his period of industrial training at the particular mills where his work leads him. His educational training, owing to the fact that he must cover a wide range of subjects, must be carefully planned so that a maximum of fundamental subjects can be given him in the all-too-brief period of academic training. Where he has taken at least five years of intensive educational training he should emerge with enough knowledge of fundamental forestry subjects to give him a professional forestry background. He must be thoroughly grounded in the fundamental sciences such as mathematics, physics, chemistry and botany; and, receive sufficient training in English courses so that he will be able to express himself clearly and correctly by the spoken and written word. He should have a fundamental course in statistical methods so that he can efficiently and correctly correlate and explain the results of his

research work. This is one piece of educational equipment which is greatly needed but is often omitted from forest school curricula, although the recent tendency in forest schools is to include it if possible.

There is no substitute for the training offered in these fundamental subjects. Once having acquired a thorough grasp of these fundamentals, the student can then seek to round out his preparation in the general field of forestry with the required courses offered by the particular school. Following this will come such subjects as are essential to the particular specialization which the student has selected as his life work. The system of a prescribed minimum of required fundamental and forestry courses accompanied by lists of elective courses so arranged that they are in groups corresponding to definite specializations, lends itself readily to the development of specialized lines.

The type of specialization has a very definite effect upon the selection of certain preparatory or rudimentary courses. In the cases where the preparation is for work in the lumber industry, a good course in lumber manufacture including forest products is essential. For the man who chooses to specialize in kiln drying, there is the need of a well-grounded course in the principles of lumber seasoning and so for every phase of specialization. For the wood chemist, the wood technologist and the wood pathologist there is even greater need for broader fundamental training. The wood chemist, for example, must not only be highly trained in his specialized line of organic chemistry but he must first have the fundamental sciences, the rudiments of forestry, the principles of economics, and sufficient theoretical and practical knowledge of the lumber and wood products industries to give him a background upon which to build his future research work. Much of the practical industrial background can be gained while he is undergoing his industrial training yet there are certain couses which he should take while in college which can not readily be substituted by work or observation at the lumber mill or by-products plant. And, of course, there is no college cocrse which can endow him with a practical viewpoint and good common sense. Nor can a course be organized which will produce native ability of the kind which uses effectively all of the tools of education and training in a successful solution of a problem or in the economic management of an industrial unit. Some of these requirements are inherent in individuals and cannot be copied from books yet they are, nevertheless, very essential requirements, for the character of the individual is still a factor in any walk of life.

Perhaps we have discounted our psychologists too much or they have not had the time to spare on the study of foresters, at any rate, mental attitudes and reactions are as important in young men who plan to take their place in the lumber industry as in any other industrial activity. The young man who cannot acquire the industrial viewpoint or who is impatient to skip the drudgery of the "breaking in" process will soon find himself unfitted for work in a field which constantly calls for the practical application of knowledge and for financial consideration of every step in the development, improvement, manufacture and marketing of new and staple wood products. Patience with slow progress, faith in the progress of the industry and loyalty to those with whom he is associated are just as essential to his success as are his grasp of educational and industrial principles.

INDUSTRIAL TRAINING

The industrial training, as I envision it, is something which, although tied in with certain college courses, is still a thing apart. It is more in the nature of an industrial apprenticeship in which the stu-

dent in periods when he is not attending school or at the end of his educational training, enters the chosen industry as one of its laboring units with the sole purpose of learning what it is all about. Most forestry students receive this type of training in one form or another, but few of them deliberately select the specialized activity, or have the tenacity to follow this training through to the end. I have known students who desired to specialize in some phase of the lumber industry but who early faded out of the picture and passed on to other fields because they could not visualize the need for working in the mill yard as a lumber piler or laboring in the logging camps as brushpiler or timekeeper. The lumber industry is a business, and for any man to successfully become a part of it he must submit himself to a period of training which will give him an understanding of the principles and practices of each step in the harvesting, manufacturing and marketing of the products. Unless this is done, as least for the steps which are involved in the particular work he will be asked to undertake, he will find himself handicapped and in some cases failure may result. The willingness on the part of the newly graduated student to accept this period of industrial apprenticeship as a necessary step toward establishing himself in his chosen professional work, is an essential requirement for the training of any industrial forester.

SUMMARY

The broadening of the field of professional forestry emphasizes more and more the need for specialized training in each distinct branch and for careful selection of fundamental and required courses in the educational training. Forestry as such is already a highly complicated subject and when the knowledge and experience of an industry must be coupled with it to produce an industrial forester, additional thought must be given to the selection of courses and to the development of specialized study.

Two types of skill, manual and mental, are required of this type of forester, perhaps in greater abundance than for other types. The great variety of activities in which such a forester may be asked to engage calls for manual skill above the average.

The mental skill required is, of course, versatile and at once intensified in order to fit the professional man for a wide range of activities within such an industry. The student must first possess the traits of character and the viewpoints which adapt themselves to the particular kind of activity chosen. He must combine practical knowledge of a complicated industry with an intensive knowledge of such sciences and arts as are essential to his professional work.

The educational training should stress a mastery of the fundamental sciences, of the required forestry courses, of a practicing knowledge of such subjects as English, statistical methods, economics, lumber manufacturing and wood products, seasoning of wood, wood technology and others; and should favor a type of curriculum which furnishes these essential courses and also makes possible the selection of elective courses grouped under heads which give the student an opportunity to specialize in his fourth and fifth year of college. Five years of educational training for certain specialized subjects is essential. If possible the elective list should be flexible enough to permit a number of cultural courses related or unrelated to the general curriculum. The prospective professional forester should, lastly, either during or after gaining his educational training, endeavor to acquire by working contact with the various steps, a practical knowledge of the harvesting, manufacturing and marketing of the wood products produced by the branch of the industry he plans to enter.

A New Species of *Synthyris* From Idaho

By FLOYD W. GAIL and FRANCIS W. PENNELL

It is a curious fact that the portion of northern Idaho traversed by Lewis and Clark on their course from the Bitter Root Mountains to and from the Columbia River should still remain one of the least known sections of the United States. Until the recent roadway over Lolo Pass, no highway that crossed the main mountain axis existed between Lookout Pass and Gibbons Pass. The section has remained scarcely explored botanically, and the very identities of certain of the species obtained by Meriwether Lewis wait for collections still to be made near the Lochsa Fork of the Clearwater River. But the few plants gathered on their difficult return journey in June of 1806 are but an insignificant proportion of the species actually growing there, and we are discovering that from the Clearwater Valley on the north to the Payette Valley on the south occurs a peculiar flora with many endemic species.

Cool water Mountain lies in the Clearwater Valley, between the lower courses of the Lochsa and Selway Forks (or Rivers), which a few miles to the westward unite to form the Middle Fork of the Clearwater River. It is in the northern part of the present Idaho County, Idaho, and within sight of eLwis and Clark's route which followed the divide north of the Lochsa Fork. Expeditions from the University of Idaho are now reaching this section, and on one of them was found the remarkable new species now being described. It grew in Douglas Fir Spruce Type, partly shaded places, Cool Water Mountain, Selway National Forest, Idaho County, Idaho, at 6500-7000 feet altitude, collected in flower May 8, 1936, by Floyd W. Gail, in United States National Herbarium. Also gathered in fruit on July 11, 1936, by Professor Gail and Elbert M. Long.

In the account of *Synthyris* presented over three years ago in the Proceedings of the Academy of Natural Sciences of Philadelphia (85: 83-96), this would have nearly all the characters that in the key distinguish *S. schizantha* Piper, of the coastal mountains of western Washington and Oregon. The two species are closely related, sharing the correlated features of finely divided petals and strongly bilobed capsules, the former being a nearly unique character in the Scrophulariaceae. Yet, as would be expected fro mthe remote and restricted areas in which these species occur, there are important differences, which may be seen in the following contrast:

A. Corolla 5 mm. long, much exceeding the sepals; anthers about 0.8 mm. long; capsule 6 mm. wide, the cells horizontally spreading; seeds dark brown, 1.3 mm. long, nearly circular (slightly longer than wide); flowering shoot below inflorescence with a single pair of ovate-flabellate leaves (about 2.5 cm. long and wide); foliage leaves more coarsely lobed, the incisions 5-15 mm. deep, the lobules acute or acutish, the leaves becoming glabrous (at least on the upper surface). *S. schizantha.*

B. Corolla 2.5 mm. long, slightly exceeding the sepals, anthers spreading; seeds yellowish brown, 1.6 mm. long, nearly oval; flowering shoot below inflorescence naked or with a pair of bract-like rounded-serrate leaves (less than 1 cm. long and wide); foliage leaves crenately lobed, the incisions 2-5 mm. deep, the lobules rounded, the leaves permanently sparsely pilose (at least on the upper surface). *S. platycarpa.*

From the width of the capsule, relative to its length, we propose calling this plant

Synthyris platycarpa, spec. nov. It may be described as follows:

Plant becoming glabrate. Petioles at anthesis 5-7 cm. long, at fruiting becoming 8-14 mm. long, at first white-pubescent, later hairy only on upper surface, elsewhere glabrous; leaf-blades rounded-cordate, bright green, above pilose, beneath eventually glabrous, the margin with about 25 or 27 shallow lobes, (2-5 mm. long), each of which is irregularly crenately bidentate, the blades reaching 5-7 cm. long, 7-9 cm. wide. Flowering stems permanently erect, sharply 4-angled, at first densely pubescent with white hairs, distally closely pubescent with shorter hairs; the stems becoming 20-30 cm. tall, below the inflorescence naked or with a pair of short bract-like rounded-serrate leaves. Bracts lanceolate or nearly ovate, acuminate to obtusish, entire to irregularly serrate. Pedicels in anthesis densely white-pubescent, shorter than or about equaling the bracts, in fruit 6-8 mm. long, strongly ascending, finely pubescent, a few hairs obscurely gland-tipped. Sepals lanceolate, attenuate, entire or slightly lobed, 2 mm. long. Corolla 2.5 mm. long, blue-violet, tube hardly 0.5 mm. long, sparsely short-hairy within; the lobes all laciniately pinnatifid, the posterior 2 mm., the anterior 1.5 mm. long. Filaments 2-2.5 mm. long. Anthers 1 mm. long, brown. Capsule 2.5 mm. long, 4.5 mm. wide yellowish-brown, widely and shallowly notched, the rounded lobes ascending. Seeds yellowish-brown, oval, flattened, 1.6 mm. long.

(Planta ultimo glabrata; folia rotundata-cordata, pilosa vel subtus glabrescens, aequaliter lobata, lobis dentibus rotundatis obsitis; pedunculus 20-30 cm. altus; pedicelli 6.8 mm. longi, pubescentes; sepala 2 mm. longa, attenuata; corolla 2.5 mm. long, caerulea, lobis laciniatis tubum excedentibus; capsula 2.5 mm. longa, biloba, blabra; semina 1.6 mm. longa.)

Continuous growth of Northwest Scientific Association through a decade and a half attests the usefulness of this organization. The various projects which it has initiated and is carrying forward—annual meeting, publication of research papers, inauguration of the Flint Memorial Fund and the Trustees' Fund all with uniform success tell us we must go on. There is no turning back. Encouragement of young scientific workers by publication of their work, financial aid to more seasoned investigators to enable them to carry on in their spare time and the needed interchange of ideas and the cooperative planning of research for utilization of the scarcely touched resources of the great Northwest are worthy ideals for a scientific organization and should stimulate increased interest in our work. It is not too early now to make plans for the 1937 December Meeting which is announced for December 28 and 29.

A note in SCIENCE (April 30, 1937, p. 429) may be of vast importance to the Northwest and all other fruit producing regions when fully investigated. Dr. V. R. Haber's discovery several years ago that Epsom salts (Magnesium sulphate) was an insecticide has been further investigated at the University of Oklahoma, by Frings and Frings. They used: Bran 60%, molasses 15% and Mg SO_4 moistened with water for grasshopper bait with success and suggest the use of this salt for all mandibulate insects. Its cost is far lower than arsenical sprays and danger of many kinds and cost of washing fruits is saved. The salt is harmless to mammals.

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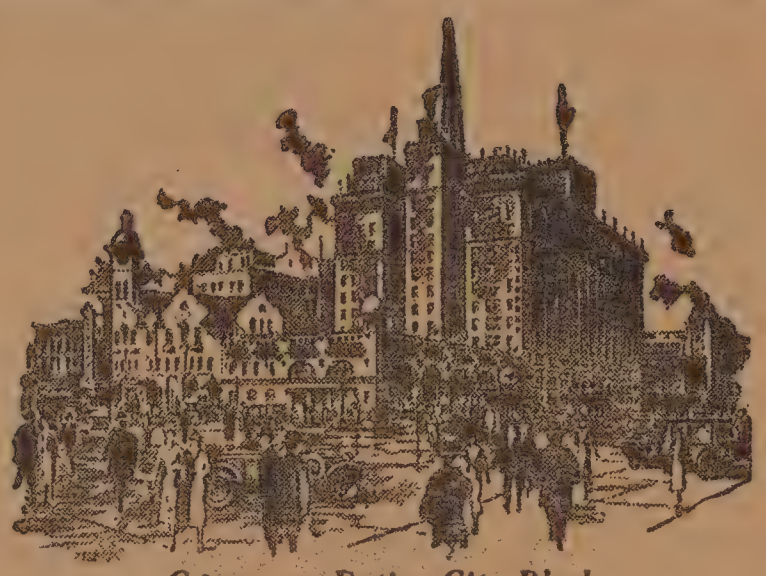

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DR. S. E. LAMBERT

SAMUEL ERNEST LAMBERT

Born at Clifton, Alabama, February 24, 1875, the greater part of Dr. Lambert's boyhood was spent at Mobile, where he received his early education in grade and high schools. From the Alabama Medical School he received the degree of M. D. in 1901. In 1902 he entered the United States Army with rank of First Lieutenant and Assistant Surgeon. He was graduated from the Army Medical School in 1903 and served for several years in the Philippines, leaving the Army with rank of Captain in 1907. In 1908 he set up practice of medicine and surgery in Spokane, Washington, which

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continued, with only the interruption of the World War, until his death, July 23, 1937. He was recognized in the medical profession by his election to Fellowship in the American College of Surgeons.

In 1908 he was married to Helen Flemming of Spokane. To them were born three children, Samuel E., Jr., of Tulsa, Okalhoma; Virginia (Mrs. W. H. H. Cranmer), San Diego, and Edward Carey, a senior in Harvard University.

Dr. Lambert's service in the World War is considered by his colleagues as deserving commendation as high as that of any other serving from the Inland Empire. He organized, in Spokane, C unit of the Red Cross. These units consisted of twelve medical men, a group of nurses and some fifty enlisted men. Arriving in France early in 1918, this unit was assigned to a station on the Marne directly in line of the great offensive of that year against Paris. Here Colonel Lambert's early army experience served him well, as he knew the procedure for securing needed supplies and personnel where official red tape prevented the less experienced. In the buildings of an old school, supplemented with temporary structures and tents, he built up a 1000-bed hospital fully equipped and manned. Here, as the offensive proceeded, were received the wounded directly from the first aid stations at the front, for emergency surgical aid, to be evacuated the following day, where possible, to the camp hospitals in the rear. This hospital became noted for its efficiency and its ability to respond to any demand made upon it. The executive ability of our soft-spoken, gentle doctor shone with brilliance during these months of the battle before Paris. The French Government recognized it with the decoration with the Order of Palms. Those remembering the history of the World War will realize that the staff of the C unit were veterans before the generalty of American soldiery had been exposed to fire.

In the establishment of Northwest Scientific Association Dr. Lambert early became a member and served as an officer of the Section of Bacteriology and Medicine and as a member of the Board of Trustees. His counsel was sought and his advice relied on to a great extent by the committee working out the revised constitution. He grasped the great possibilities of the Inland Empire sociologically as well as industrially and of the need of a leadership with broad vision to coordinate cultural and economic factors. None realized better than he that much of our collegiate education in science seemed designed to furnish other sections of the country with selected youth from this region while little of it directs that youth to the need of research on problems of our own. In the passing of Dr. Lambert, culture, science and the profession of medicine suffers a great loss.

Extensions of the Ringold Formation[1]

By HAROLD E. CULVER

Supervisor of Geology, State Division of Geology, Pullman, Washington

Just a little more than twenty years ago Merriam and Buwalda made an examination of the sedimentary rocks exposed in the White Bluffs on Columbia River. After measuring and describing the section there exposed, they determined the fossils it contained and gave the formation the name Ringold, from the type locality near Ringold Post Office.

It is worth while for us to note that Merriam and Buwalda were especially concerned with the relation of these beds to the Ellensburg formation. A correlation had been suggested by Russell in 1893, and followed by others, including George Otis Smith, who noted the fluvial origin for the Ellensburg near Yakima and the apparent lacustrine origin for the beds at White Bluffs. Calkins, who described the type section of Ellensburg, noted in 1906 that there were some points of contrast between the two, but that some parts of the White Bluffs beds were probably of fluviatile origin.

It will be recalled that a tooth of the genus Hipparion had been reported from the type Ellensburg. According to Merriam and Buwalda, such poorly preserved bones of representatives of the horse family as were found in the White Bluffs beds indicated that they were not only distinct from, but considerably later than the type Ellensburg beds. Teeth from the Ringold area are "at least as advanced as those of Equus occidentalis from the Pleistocene of Rancho La Brea, and may be even more specialized."[2] Bones of camel, deer, ground sloth, and equid types, while possibly late Tertiary in age, "seem more advanced than any fauna known heretofore in the Miocene of the Pacific Coast and Great Basin provinces."[3] And further: "the collection from near Ringold School taken by itself would be considered to represent Pleistocene."[4]

A section totaling 503 feet of light-colored muddy sandstones and sandy clays, with minor parts of fine gravels, volcanic ash and calcareous strata, was measured by Merriam and Buwalda. It is well to note that they observed and recorded several features of importance:

1. The material is not thoroughly classified nor sharply stratified;
2. The coarser materials are waterworn;
3. The strata lack induration and are notably softer than most exposures of the Ellensburg;
4. The remarkably even surface extending several miles eastward is probably a surface of aggradation;
5. The apparent absence of freshwater molluscan remains, together with the mammalian fossils, indicates the deposits to be flood-plain sediments;
6. Occasionally beds of coarse angular materials, chiefly basaltic, are found at the top of the Bluffs, evidently laid in channels cut in the Ringold.

No attempt was made to determine the areal limits of the formation, but it was thought to have originally extended from the Saddle Mountains on the north and the Yakima Range on the west, to the "lava plateaus on the east and south."[5]

An eastward extension of the Ringold from the type locus was implied in the original article by Merriam and Buwalda. Hence it is not surprising to find that it is readily traced to Esquatzel Coulee in the vicinity of Eltopia and northward near Connell. This is the southern portion of the area mapped by Bretz as "Channeled sedimentary rocks above the basalt."[6] Northeast of Connell it is exposed in many places along the highway, but is

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generally concealed beneath wind-blown sands and silts. It can certainly be recognized north of Ritzville, but studies have not been carried much beyond there, so its full extent is not determined. East of Connell the Ringold is well exposed at McChesney Springs where erosion by both stream and wind has provided the loose sand of the picturesque dunes. It is interesting to note that silicified fossils representing most if not all of the forms found in the type locality of the Ringold have been collected from these beds. There would seem to be no doubt that these beds and those of the type Ringold occupy identical stratigraphic positions.

Although these McChesney Springs beds were not recognized by Bretz as "channelized sediments above the basalt," he has mapped several interesting exposures of such beds nearly as far east as LaCrosse in Whitman County. In addition many of the "prow-pointed hills"[7] of Bretz can be shown to comprise at least two distinct stratigraphic units, a top of wind-blown silt or sand, the "palouse soil" of many writers, and an underlying siliceous silt, clay, or sandstone, distinctly more resistant than the overburden. There seems to be no reason for not considering the possibility of this lower member being the eastern representative of the Ringold formation. Several other angles of this correlation have been under study for the past decade, but it suffices here to say that essentially all data point to this conclusion.

The northward extension of this formation is quite different from that suggested by Merriam and Buwalda. Not only do these beds lie on the north slope of Saddle Mountain, but clearly extend farther west. The close structural similarity of the Ringold beds and the basalt, both on the Saddle Mountain uplift and in the surrounding tracts, makes it difficult to follow the original idea of Merriam and Buwalda that this formation "originally extended up through the gap which the Columbia has cut across the Saddle Mountains, and that it was deposited over areas north of that range."[8] Instead it seems clear that this deposition took place prior to the Saddle Mountains uplift and extended northward past Othello and beyond Moses Lake, spreading westward to cover the now upwarped tract of Frenchman Hills. Field studies have not yet been carried far enough north to even suggest the limit in this direction, but preliminary observation of the region suggests that it may be north of Columbia River.

On the south the extension is less carefully studied to date. There seems no reason to believe that the beds did not originally extend over the present crest of the Rattlesnake Hills just as they did over the Saddle Mountains and Frenchman Hills. Certainly remnants can be found along the south slopes near the Sunnyside gap, and other exposures of similar beds seem to fit in with this idea. On the south side of the downwarped and eroded Yakima Valley are still other exposures of Ringold-like sediments, even on the south slopes of the Horseheaven Hills. In view of the similarity in structural history of these uplifted tracts it is evident that an original extension to some point south of the Horseheaven Hills uplift can be postulated safely. How much farther is not clear on present data.

The westward extension is even more interesting than those in other directions. This has been suggested previously in a paper on the Ellensburg formation presented in Seattle last June.[9] In this direction, instead of being confined by the rocks of Yakima Range, the deposits, as traced by remnants still discernible, appear to have originally extended beyond the Yakima in the Selah region. A large part of the formation originally defined as Ellensburg seems in truth to be distinctly later in origin than that formation. There is no doubt that some post-basalt beds of true Ellensburg type and relations were originally laid down in this area,

for remnants of them are readily observable today. Still it appears likely that much of the clastic material designated as Ellensburg in the Selah area is in reality stratigraphically and structurally referable to a later time than the true or type Ellensburg. If this be so, much of the overlying series of sands and gravels would appear to be part of the widespread Ringold formation.

In support of this idea are two significant facts. First, the fossils by which the type Ellensburg formation was identified as Miocene were found in but two places. The tooth assigned to the genus Hipparion was sent from the Yakima region to Doctor Condon in Oregon, but the exact locus of its discovery remains in doubt. Careful examination of possible sources by our Secretary, Mr. Thompson, has led him to the conclusion that the tooth was probably found in the sandstone quarry near Thorp, about five miles south of the city of Ellensburg. These beds of sandstone are like the true Ellensburg rather than the less indurated and less well stratified Ringold. The plant fossils, on which more reliance as to age has been placed, came from Kelly Hollow, where undoubted Ellensburg beds only are exposed. No fossils have been found in that portion of the "Ellensburg" here assigned to the Ringold.

Field examination of the beds of both formations leads to the conclusion that there are recognizable structural differences between them. While both formations have been deformed by warping, only the Ellensburg beds have suffered marked deformation. In several places near Selah the two series appear to be unharmonious in structure. Insufficient work makes it impracticable to state with certainty that this is a feature by which the two series can always be distinguished or can be separated in all places. Indeed this would seem to be improbable in view of the deformation which has affected the later Ringold formation. Yet it is certainly significant that where comparison is possible, the distinction seems to hold.

These extensions of the area on which the Ringold was formed justify reconsideration of its stratigraphic features.

The lithologic and sedimentational character of the component parts serves to reaffirm the idea brought forward by Merriam and Buwalda that the Ringold is a sort of flood-plain deposit. That it could not have been the deposit of any one stream, such as the Columbia, is clear from the extent of the area over which it was formed. Rather it seems to suggest a general and widespread filling of the Columbia Basin from a number of directions and by several agencies. Under this concept, the Ringold would be expected to show the varied character which it exhibits, both as to materials and as to other stratigraphic features. There would be expected, locally, current embedded sands and gravels, deposits made upon mud flats, local pond or lake deposits, and without doubt deposits referable to wind action. All these types are recognized.

As to age, several factors may be considered. It is clearly post-basalt, and since no beds other than Ellensburg have been recognized between the Ringold and the basalt, the Ringold must be called post-Ellensburg. Until more decisive data are discovered the later basalts of the Columbia series and the Ellensburg must be left in the late Miocene. As yet there is no reported correlation between the Ringold and the recently recognized Pliocene of northern Oregon.

The strongest evidence as to age is of course that of the fossils recorded by Merriam and Buwalda previously noted. But in addition, there is the relative lack of induration, which in spite of its apparent insecurity, comes to be looked upon by experienced workers as a valuable guide to stratigraphic position. There is also the prominent trenching of the upper surface, locally resulting in the complete elimination of the Ringold, a feature noted

by practically every worker in the field. It is clear that later glacial waters, at least, have been operative after the deposition and warping of this formation.

Post-Ringold structural changes clearly involve the uplift of the Frenchman Hills tract and that of the Saddle Mountains, Rattlesnake Hills and Horseheaven Hills probably should be included. In the Saddle Mountains not only has the Ringold participated in the warping, but the extensive faulting of the lavas has affected these sediments also.

Post-Ringold sedimentation history appears simpler, on the whole, than the Ringold history itself. It is largely a record of general erosion with some local continental deposition. Without doubt most of the so-called "Palouse soil" of Whitman County is not only post-Ringold, but derived from that formation in large part. Farther west the surficial sediments are generally more sandy than in the Palouse region as would be expected from the generally coarser character of the Ringold beneath them there.

In a recent article, Professor Beck, of the Ellensburg Normal College has suggested that the calcareous layer at or near the top of some of the Ringold exposures was either "a hardpan subsoil zone" or, as he thought more likely, "the result of leaching from one of the earlier Pleistocene loess mantles."[10] Probably every careful student of this interesting calcareous zone has noted its obvious secondary nature. It is clearly a cementation zone in which lime carbonate has been concentrated. But in the original White Bluffs section, as noted by Merriam and Buwalda, the lime layer lies some 85 feet below the top of the Ringold section. If this be true, it may be necessary to modify the concept set forth by Professor Beck so as to bring out more clearly the relation of the lime zone to the fluctuation of the water table.

It is obvious that the problems of the Ellensburg, the Ringold, and the Palouse are inextricably intermingled. Little progress on any one has been possible without giving a good deal of consideration to the others. For purposes of presentation, however, it has seemed advisable to discuss each formation separately, and in chronologic order. I hope to complete the preliminary paper on the Palouse at an early date, so as to bring out the interesting inter-relations which are indicated.

By way of summary it may be said that the Ringold can be looked upon as extending much more widely than first suggested by Merriam and Buwalda. It appears to have been a rather general filling of the Columbia Basin. Sedimentary materials appear to have come from all sides with the recently uplifted rocks along the west margin furnishing the major portion. The usual continental agencies of erosion and deposition appear to have been operative. The Ringold deposition certainly preceded the uplift of the Frenchman Hills and the Saddle Mountains, but the formation has subsequently been trenched by streams of late glacial time, probably those related by Bretz to his Scabland Flood. Still later, and continuing even today, the original Ringold deposits appear to have been furnishing most of the material making up the substance of the Palouse soil.

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[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

[2] Merriam, J. C., and Buwalda, J. P., Age of strata referred to the Ellensburg formation in the White Bluffs of the Columbia River: Univ. of California (Geol.), Vol. 10, No. 15, 1917, p. 259.

[3] Ibid., p. 259.

[4] Ibid., p. 259.

[5] Op. cit., p. 263.

[6] Bretz, J. H., Geog. Rev., Vol. XVIII., Pl. V., 1928.

[7] Bretz, J. H., Channeled scablands of the Columbia Plateau: Jour. Geol., Vol. XXI., 1923, p. 625.

[8] Op. cit., p. 265.

[9] Special meeting, Geol. Soc. America, Cordilleran Sec.

[10] Lime-rock zone of Columbia Basin: The Mineralogist, Nov. 1936 (Portland, Ore.).

Notes on Vashon Stage Glaciation of the South Fork of the Skykomish River Valley, Washington[1]

By ALLEN S. CARY and CHARLES W. CARLSTON
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Two distinct glacial stages[1] have been recognized in the Pleistocene history of the Puget Sound lowland, an earlier Admiralty Stage and a later Vashon Stage. The Vashon glacier, which filled the lowland as far south as the Chehalis River, left on retreat a partly drowned topography of parallel valleys and drumloidal hills composed of Vashon till molded around cores of fluvial and lacustrine sediments which had been deposited in the preceding interglacial stage. The consistent north-south alignment of these features shows clearly that they were formed by a great glacier moving southward from British Columbia. Flanking the lowland are high mountain ranges, the Cascades on the east and the Olympics on the west, which bear evidence of severe local glaciation in their serrated ridges, many cirques and broad, straight, U-shaped valleys. A few small glaciers, probably remnants of the mightier alpine glaciers of the Vashon Stage, still occupy protected cirques in the mountains. The relations of these local glaciers of the Vashon Stage to the main ice sheet in the Puget Sound lowland presents an interesting problem.

Bailey Willis[2] and J. Harlan Bretz,[3] who have made the most important contributions to the glacial history of the Puget Sound region, have expressed somewhat different views on this problem. Willis, whose investigations were confined largely to the region just west of Mt. Rainier, believed that the main sheet of northern ice received considerable contribution from the local Cascade glaciers, while Bretz, whose reconnaisance studies extended all along the mountain front, held that the local glaciers had contributed little or no ice to the main sheet.

The writers have recently studied the glacial deposits in the valley of the South Fork of the Skykomish River, which is located on the west slope of the Cascades about midway between the Canadian boundary and the terminal moraine of the Vashon ice in the Puget Sound lowland. The work was undertaken as part of a general program of research on the Pleistocene glaciation of the Puget Sound region, under the direction of Professor J. Hoover Mackin of the University of Washington. Absence of critical lines of evidence makes a complete statement of the history of the valley impossible but it is felt that certain general conclusions, which bear on the problem outlined above, are worthy of note.

Rising in the high Cascades, the South Fork of the Skykomish River flows through a broad, straight, U-shaped valley before leaving the mountains to flow across the Puget Sound lowland. At the point where the river issues from the mountains its valley is constricted by a high ridge of till and outwash material. On the north side of the stream the ridge has the form of an ice-contact terrace with a pitted ice-contact slope resembling a huge amphitheatre, facing to the west or toward the lowland. The general level of the terrace is about 1850 feet above tide or 1450 feet above the river. Excellent sections in the cut made by the stream across the constricting ridge disclose south-dipping, delta-bedded silt, sand, and gravel, interstratified with lake clay and till sheets. The coarser sediments of the delta grade eastward into warved and laminated lake clays, 600 feet in maximum thickness, which extend several miles up the mountain valley. No glacial till has been found overlying or underlying the up-valley extension of the clays. Farther up-stream, in the main valley and its tributaries, there are glacial moraines of local

origin, but whether these mark the terminus of the local valley glaciers or merely recessional stages cannot be determined with any degree of certainty.

The above described features suggest that during the later part, at least, of the Vashon Glacial Stage, a lake was dammed in the valley of the South Fork of the Skykomish River by the Puget Sound glacier. An ice-marginal stream from the north emptied into the lake, forming the ice-contact delta which grew out chiefly from the north side of the valley during the deposition of warved and laminated clays in quiet water farther up the valley. The highest level at which thees clays have been found is 1100 feet above sea level, but the lake certainly filled the valley to a height of 1800 feet at the stage of maximum delta growth. Interstratification of till sheets in the delta indicate that the Puget Sound ice was by no means stagnant at the time of deposition of the valley filling sequence.

It is clear that the lower part of the mountain valley of the South Fork of the Skykomish River was not occupied by locally derived ice during a late stage of Vashon glaciation when the main ice stood at a level of 2000 feet or more opposite the valley mouth. This relation supports the views of Bretz in regard to the relative strength of local and northern ice. It must be kept in mind, however, that the features described here may be records only of the final stages of the Vashon glaciation, and that the relations of the northern and local ice may have been decidedly different earlier in the Vashon Stage. It must also be remembered that the conclusions of Willis were drawn from field work considerably to the south of the Skykomish and that it is likely that the local glaciers descending from the flanks of Mt. Rainier were larger than those of the Skykomish Valley.

[1] Bailey Willis, Drift Phenomena of Puget Sound, Geol. Soc. Am. Bull., Vol. 9, pp. 111-162, 1898.
[2] Bailey Willis, op. cit.
[3] J. Harlan Bretz, Glaciation of the Puget Sound Region, Wash. Geol. Survey, Bull. No. 8, 1913.

The State Line Earthquake at Milton and Walla Walla[1]

By BENJ. H. BROWN
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On two occasions in the writer's experience the senses failed to coordinate. The first time a pilot sent his airship into a tailspin and the passenger seemed to see the earth and the sky roll around over each other. The second time was at 11:05 p. m. on July 15, 1936, when the region around Milton, Oregon, and Walla Walla, Washington, was so shaken in an earthquake that many persons left their beds for the outdoors in haste and perturbation with various styles of deshabile. The writer's house at the north city limits of Walla Walla shook and rattled, and rumbled, and groaned, and squeaked, imitating closely the work of a jazz orchestra, without any permanent damage.

The first and main shock was followed by lesser aftershocks at 11:23, 11:25, 11:30, 11:56, 12:10½, 12:25, 12:27½, 12:38, 1:00, 1:10½, Western Union time, to the minute. Occasional aftershocks have been felt ever since.

Many chimneys were broken, several houses moved an inch or less on their foundations, stacks of boxed and canned goods and shelf wares were scattered over floors with some damage. In one house a half mile west of Ferndale a brick chimney broke at the roof and at the ceiling. The part above the roof was rotated and left standing. The attic portion of the chimney fell to the northward, breaking through the ceiling and strewing

bricks and mortar over the kitchen furniture. A two-story concrete house one mile west of Umapine shed some of the top of the second story wall. The owner has restored this house by moving the second story concrete and lowering the roof to make a one-story house. One fine country residence suffered the complete loss of a large fireplace chimney, and the porch of this house settled two inches, leaving the house roof extension hanging without support. The ornamental railing of cement posts on top of a cement block office building in Freewater was greatly damaged, much of it being thrown southwards to the sidewalk. A brick house at the penitentiary used by the warden has been condemned as unsafe. The writer estimates the loss at $100,000. Repairs on the Milton-Freewater school buildings cost $8500. Many cracked basement and plastered walls may never be repaired, but these are included in the estimate. Many capstones in the cemeteries were rotated, the free corner moving usually less than an inch. About 70 per cent of stones rotated clockwise, viewed from above. Stones in close proximity in some cases rotated in opposite directions.

The quake did some useful work. Several springs are reported to have been revived by the shocks. On the farm of Julius Jensen about four miles south-southwest of Walla Walla is an artesian well 600 feet deep, which, when first drilled, spouted water eight feet above the surface. As other wells were drilled, the flow weakened until a pump was installed to raise the water to the surface. The earthquake revived this well and it now throws a four-inch stream several feet from a horizontal pipe 2½ feet above the surface. This well at present shows no signs of diminishing its flow.

A spur of the Blue Mountains, known locally as the Touchet Ridge, extends from Milton west-northwest, crossing into Washington about five miles east of Wallula. The ridge crossed the Columbia River at one time, damming the water to form a large lake. The north edge of Touchet Ridge in places is very abrupt, the layers of basalt being broken square off at Milton, and marks an old fault line. North of the ridge lies the valley of the Walla Walla River and its tributaries.

Superposed on the old fault is a more recent fault extending from Milton about 20 miles down the valley. The basalt floor underlying the Milton-Walla Walla region has dropped 600 feet below the average gradient of the valley. The south edge of the depression lines up closely with the old fault line, whereas the other sides of the depression slope up gradually to surface exposures of basalt four miles east of Walla Walla, six to eight miles north of Walla Walla, and two miles west of Touchet. No evidence of fracture has been found on the east, north, and west sides.

This local depression has been the site of three successive lakes, as described in a former paper before the Northwest Scientific Association. Alternating layers of lake sediments and river gravels have accumulated to fill this area to meet the common gradient of the valley. A fourth lake in glacial times covered the depressed area with a layer of sediments whose maximum depth is known to exceed 100 feet. Most of these later sediments have been carried away by the Walla Walla River system. Thus, the depressed area has been subjected to varying loads of considerable magnitude.

Between the towns of Milton-Freewater and Umapine are several earthcracks up to three inches in width, some a few feet long, others have been traced 200 yards. The general direction of the cracks is west-northwest, or roughly parallel with the Touchet Ridge fault line. The destructive effects of the earthquake seem to be strongest along the line of these cracks. In a Milton store a small scale pen was jumped out of its socket, showing a vertical life at this point. Three or four miles

north of the line described is another line of cracks also roughly parallel to the old fault line. One crack, when examined November 15, was at least one foot wide. Possibly this width was due partly to sloughing off of the side walls, as the crack was filled to within a foot of the top by loose earth. One wall of a cut in the State Line highway running east and west slumped to such an extent that the loose dirt flowed completely across the driveway.

The buildings in the earthquake area are so irregularly distributed and their character and condition so varied that it has been impossible to fix with accuracy the destructive limits.

So much for the facts.

Now, the writer, with the characteristic abandon of the amateur, suggests that the south line of destruction marks the epicenter, and the north line marks the position where the waves emerged at the angle of greatest destruction. And, lastly, with even greater abandon, he suggests that the earthquake was due to an upsnapping of the basalt folor due to removal of the load as above described.

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[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

Evaluation of Jurassic Intercontinental Correlations[1]

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The Jurassic faunas of Europe have been the subject of detailed study since the beginning of the 19th century. The result has been a subdivision of the European stratal and faunal sequence in a degree of detail far beyond that attained for any period in North America.

The most detailed subdivision of the Jurassic so far attempted is that of S. S. Buckman. His intensive studies of the English Jurassic faunas and stratigraphy, beginning in 1880 and ending in 1927, have resulted in a chronologic subdivision of the Jurassic period into 47 ages and 350 hemerae. Each age is named from the characteristic ammonite genus or family that reached its maximum development at that time, and hemerae, the subdivisions of ages, are named from a characteristic genus or species.

Coincident with the development of the chronologic scale Buckman undertook an extremely detailed subdivision of the stratigraphic sequence and an equally detailed subdivision of species, genera, and families of ammonites, the latter being regarded by many as excessive and unreasonable "splitting." Under Buckman's conception each species is confined to a single hemera and genera do not range through more than four ages. By way of comparison, it might be said that a genus of ammonites, as defined by Buckman, is of about the same magnitude as a species of most authors.

The marine Jurassic rocks of North America are too poor in fossils, too incomplete, discontinuous, and imperfectly known to permit the working out of their relations except by correlation with the well-known sequence of Europe. The chronology established by Buckman is gaining acceptance in this country and most of the intercontinental correlations attempted by recent workers on North American Jurassic faunas have been made in terms of this chronology. In view of the exceedingly small units proposed in Buckman's chronology of 47 ages and 350 hemerae, there arises a question regarding the exactitude with which these correlations can be made.

During the past 10 years publications on the Jurassic faunas of North America

have been made mostly by F. H. McLearn and C. H. Crickmay. McLearn, working on the Jurassic faunas of British Columbia and Alberta, has been, for the most part, content to point out the affinities of his Canadian species with English species and to give the dates of those English species in terms of Buckman's chronology, implying a certain age, or part of an age, for the American species, but really leaving the reader to draw his own conclusions.

Crickmay has made extensive studies of the Jurassic faunas of North America, principally in British Columbia and United States, and has done much to call attention to the need for more exact paleontologic and stratigraphic work. He states the dates of his faunas mostly in terms of the ages of Buckman's chronology, but some dates are given in terms of hemerae. A few examples will illustrate the intercontinental hemeral correlations proposed by Crickmay. In writing on the fauna of the middle member of the Sundance formation, he states that: "The middle member contains a sparse fauna, consisting mainly of ammonites of the genus Cardioceras. . . . The date is Cardioceratan, cardia, in terms of the chronology brought together by Buckman."[2] In a paper on North American Jurassic brachiopods,[3] some brachiopod species are assigned to definite hemerae, such as mollis, Witchellia, and Epalixities, though some are referred to ages, some to stages. Eleven successive "faunas" containing one to six species each were listed for the Mormon formation of Taylorville[4] and eight of these "faunas" were referred to seven hemerae of Buckman's chronology.

For some time the writer has been engaged in a study of the central Oregon Jurassic faunas and necessarily has been much concerned with the question of how closely those faunas may be correlated with European faunas. The chronology developed by Buckman appeared to be a step in the right direction in that it proposed a sequence of time divisions which, in some modified form, might serve as a standard world-wide chronology for dating Jurassic faunas and strata. Some of the Oregon faunas appeared to permit recognition of ages, or even parts of ages, with a fair degree of certainty, but attempts to define dates in terms of hemerae always met with serious conflicting evidences. Therefore this attempt is made to bring out some facts that appear to be of importance in determining whether or not Buckman's hemerae are recognizable in North America.

Several questions must be answered in order to reach a satisfactory evaluation of hemeral correlations. Some of these questions are: (1) how nearly correct is the hemeral succession of English genera and species as outlined by Buckman; (2) how many of the hemerae are determined by local facies conditions and accident of discovery of fossil material rather than actual evolutionary differentiation of species and genera; (3) what are the bases for determining contemporaneity of European and North American faunas; (4) are these bases sufficient for the results assumed?

The first two questions cannot be answered at present. Buckman's chronoolgy is not an untried, suddenly conceived scheme—it was developed gradually over a period of more than thirty years with the benefit of much criticism. The major chronologic divisions called "ages" are frequently used by other authors, since ages are of about the same magnitude as the "zones" of other writers, but hemerae, the subdivisions of ages, have not gained general acceptance. Certainly the chronology is not correct in every detail, but sufficient time has not yet elapsed for other workers in the field to determine the validity of each hemera or to find all the inaccuracies in the supposed succession of hemerae. Since the practice of dating North American faunas in terms of Buckman's hemerae apparently assumes that the hemerae are valid chronologic units

and essentially in the correct sequence, this paper will present some facts that must be taken into account even if Buckman's chronology is correct in every detail. In this connection the bases for determining the contemporaneity of North American and European faunas will be examined.

Some difficulty is encountered in finding the bases for hemeral dates assigned by Crickmay. In most cases he has listed the species of each fauna, without explaining how he arrived at the assigned date such as "Stepheoceratan, Epalixites." As far as the writer can discern, the hemeral correlations are based mostly upon the belief that an ammonite genus, in this country, will have the same time range as the recorded time range of that genus in Buckman's chronology. Similar species are used in a like manner. In this connection a statement by Crickmay regarding "Kallistephanus sp." is instructive: it reads, "The close connection between this species and forms of this genus of sauzei date in the English Jurassic is the chief argument for dating this zone and its fauna as sauzei."[5] Apparently some ammonite genera are treated as if they were index fossils for hemerae.

In order to determine the validity of hemeral correlations based upon identical genera or similar species, it is necessary to know what time range is to be expected of the much restricted genera of Buckman and Crickmay. To secure this information, the recorded time ranges of all genera described in Buckman's last monograph, the seven volume "Type Ammonites," were compiled with the following results:

407 genera and 797 species were described, figured, and located in the chronology of ages and hemerae.

Each species was assigned to a single hemera.

Of the 407 genera, 223, or 55 per cent, had only one species each, and so each of these 223 genera appeared in only one hemera.

The remaining 184 were represented by two or more species.

Fifteen genera represented by more than one species showed ranges of two hemerae, seventeen genera showed ranges of three hemerae, and thirty-two genera appeared in three or more hemerae. The maximum recorded range of a single genus was thirty-five hemerae.

Obviously the true time range of a genus cannot be determined from only one species, so the ranges of at least 55 per cent of Buckman's genera are not ascertainable from the monograph "Type Ammonites." Since many other of the new of redefined genera of Buckman are based only on two, or three species of known hemeral location, all from one restricted area in which facies and accident of discovery, rather than time, may determine the recorded existence of a genus, it is apparent that the true time ranges of only a few of Buckman's genera can even be estimated. But the above figures show that the probable duration of even these much restricted genera is not one but several hemerae. English Jurassic species defined and dated in terms of hemerae by other authors are not sufficiently numerous to materially alter the above figures.

One example will be sufficient to illustrate the application of these facts to North American correlations. In his recent paper on the Jurassic faunas of Taylorville, California, Crickmay[6] dates the lower zone of the Lilac formation as Deroceratan age, Euechioceras hemera, on the basis of a single ammonite species which happens to be a new species of Euechioceras. This genus is represented by only one species in the chronology of Buckman and so appears only in the Euechioceras hemera. The true time range of Euechioceras might prove to be thirty-five hemera, the maximum range recorded

for Buckman's genera, if all species were known.

The recently discovered and abundant Jurassic faunas of central Oregon furnish additional information on the degree of exactitude attainable in intercontinental correlations. Here the ammonites are so abundant that a number of species can be collected from each of several small stratigraphic units. From these it is possible to make an estimate of how closely ecah fauna can be tied to the chronology of Buckman by the identical genera method because the reliability of a single genus or perhaps the correctness of Buckman's hemeral sequence, will be determined by the degree with which the age indications of a number of genera of the same fauna focus upon some particular spot on Buckman's chronology. Among the ammonites of the Nicely shale member of the Ochoco formation, for example, are species of several European genera,—Harpoceras, Platyharpites, Amauroceras, and Nodicoeloceras. On the basis of identical genera and similar species several hemeral dates are indicated, and these hemerae are spread through the latest Amaltheian age and the early Harpoceratan age of Buckman's chronology. The relative stratigraphic positions of these Oregon forms preclude any possibility of the genera occurring there in the same order in which they are known in England. Each central Oregon ammonite fauna studied in any detail has yielded the same results as the Nicely fauna—namely, the age indications of several contemporaneous ammonite species focus upon a unit of time that, in some cases, is as long as an age, in some cases smaller than an age, but do not permit the recognition of hemerae.

Similar incongruous mixtures of genera have been found in at least two instances by Crickmay. One mixture is found in the Mormon faunas of Taylorville, California.[7] Nevertheless specific hemeral dates are assigned to most of the faunas.

The other mixture was found in the upper member of the Sundance formation.[8] The explanation advanced was that "the upper member is a 'concentrated deposit' —that is, one from which in the course of deposition, much sediment was sorted out and carried away, leaving the shells of several successive ages commingled in one stratum. The fauna consists mainly of pelecypods, but also includes ammonites of four distinct ages mixed confusedly together, though no place has yet been found where a clear separation can be made." In this paper and elsewhere Crickmay has made commendable efforts to call attention to mistakes that may be made by neglecting such possibilities as reworking and concentration of fossils or by disregarding conflicting faunal evidence where careful stratigraphic separation has not been made, and the explanation advanced may be entirely correct. But there is some reason to suspect that these forms occur in different associations in Wyoming than they do elsewhere. Also the possibility that Buckman's chronology is in some part incorrect must not be overlooked.

SUMMARY. A compilation of time ranges of Jurassic ammonite genera whose dates are given in the chronology of Buckman show that even the much restricted genera of Buckman may have a time range as long as thirty-five hemerae or more than three ages. Most of Buckman's genera do not have known time ranges of more than one hemera principally because only the genotypes are known. The time ranges of many other of Buckman's genera are unknown because they are represented by only a few species each and because their chronologic positions have been determined only in England. Therefore the dating of North American faunas in terms of English hemerae is questioned, particularly in those cases where the dates are based upon one or two identical genera in common or upon similar species. The Jurassic faunas of Central Oregon bear out this conclusion.

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[1] Presented at the annual meeting of the

Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

[2] C. H. Crickmay: Study in the Jurassic of Wyoming, Bull. Geol. Soc. America, Vol. 47, 1936, p. 554.

[3] C. H. Crickmay: Attempt to zone the North American Jurassic on the basis of its brachiopods, Bull. Geol. Soc. America, Vol. 44, pp. 871-894, 1933.

[4] C. H. Crickmay: Mount Jura investigation, Bull. Geol. Soc. America, Vol. 44, pp. 895-926, 1933.

[5] C. H. Crickmay: The Jurassic rocks of Ashcroft, British Columbia, Univ. of Calif. Pub. (Geol.), Vol. 19, No. 2, pp. 23-74, 1930, **p. 61.**

[6] C. H. Crickmay: Mount Jura investigation, Bul. Geol. Soc. America, Vol. 44, pp. 895-926, 1933.

[7] C. H. Crickmay: Op. cit.

[8] C. H. Crickmay: Study in the Jurassic of Wyoming, Bull. Geol. Soc. America, Vol. 47, pp. 541-564, 1936.

Some Climatic Influences in the Regional Economy of the Rogue River Valley[1]

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The Rogue River Valley consists of an area of about 300 square miles carved out of the Klamath Mountains of southwestern Oregon by the Rogue River and its major tributaries. Its elevation ranges between 1000 and 2000 feet and the entire region is surrounded by mountains. The economic bases of the valley consist of general farming of a rather intensive nature, subsistence mining, and an increasing health resort and tourist business. Its agricultural specialization lies in pears, it being one of the three largest commercial pear producing regions in the United States.

From a general description there appears to be nothing unique about the valley that might even be the subject of a scientific study. Training, however, the technique of modern geographic analysis on this valley some interesting and distinctive environmental relationships appear.

In modern geographic analytical philosophy no natural nor cultural landscape merely occurs, either because of the whims of nature or of man. Natural or cultural landscapes are, rather, viewed as the adjustmental resultants of a long and subtle interplay of the elements of the natural environment which include climate, relief, soil, water resources, natural flora and fauna, size, shape, and location or access. The development of landscape and the economic or cultural pattern of a region tend to be an outgrowth of these elements of the natural environment as they exist in varying combinations. Climate usually sets broad bounds, but frequently peculiarities of climate have a far reaching direct influence in shaping the regional economy of an area. This situation is particularly true in the Rogue River Valley.

Climatically the valley represents the more arid phase of the Marine Temperate or West Coast Cyclonic type. Situated some 60 to 100 miles inland, with a mountain interval between the valley and the coast, certain characteristics of both a subtropical and continental nature are also in evidence. Many of the older homes in Medford and Ashland possess palm trees, and at least two pomegranates have weathered some 30 or 40 years in the town of Jacksonville.

The maximum rainfall occurs in winter. Precipitation may be as heavy as 40 to 80 inches in the surrounding mountains, but the fact that the agricultural sections in the valleys lie far below the surrounding territory, places the entire region within

the rain-shadow of the ranges, resulting in a dry valley island within the plateau. In the valley proper the average annual rainfall runs from 25 to 30 inches near Grants Pass on the west to around 15 at Medford. The minimum rainfall occurs in summer. Except for occasional light conventional showers July and August are practically rainless.

A month is cooler than is ideal if the average temperature of that month falls below 32 degrees F., and warmer than is ideal if the temperature averages above 70. The Rogue River Valley fits well into this optimum climatic range. Zero temperatures are rare, and the mean for January is between 37 and 39 degrees. Summers are hot. The means for July and August range between 69 and 71. The hottest spells, however, usually last but a week or so, and although the general temperature prevails high, the humidity is low and the sensible temperature is not excessive. Because of the cloudless skies, facilitating rapid radiation, and the nocturnal drainage of cooler mountain air into the valley basins, nights in summer are always cool. The combination of mild winters, frequent changes, warm to hot days in summer, but delightfully cool evenings and nights, is undoubtedly conducive to a maximum of human energy, and the Rogue River Valley may be safely referred to as one of the most energizing geographic regions in North America. Its climate, with the geologic attractions of lithia and sulphur-springs, Oregon caves, and Crater Lake, is thus responsible in part for the development of an important health resort and tourist industry.

There are no really destructive storms throughout the valley. During the summer steady, prevailing westerly winds blow along the strike of the valley and sometimes present minor problems. These winds appear to be drawn southward by the summer low of the arid southwest and the Sacramento Valley convection. This is evidenced by the fact that the hotter the day the more steady and firm are the winds. On a hot afternoon the winds develop such force that they tax the capacity of a powerful car pulling up the Siskiyou Mountains northbound, and truckers and drivers who are familiar with local conditions schedule their trips so that they will be southbound over the Siskiyous in the afternoons and northbound either in the evening or morning, to escape these strong head winds.

Grants Pass, lying in the wind shadow of the coastal mountains, has the second lowest average wind velocity of any station in the United States. As one progresses eastward through the valley, however, the winds increase in velocity. This increase and a prevailingly northwesterly direction means that young orchards need to be especially pruned or propped to prevent leeward leaning and excessive leeward development of the trees.

In the spring of the year there is considerable of a frost hazard in many parts of the basin. During still nights the colder air from the highlands drains into the valley bottoms. As a rule it is only on the valley floor that serious injury may result from minimum temperatures during the blooming period. Even in the valley on slight elevations no frosts may occur, while serious injury may result only a few feet below. The hillsides surrounding the valley usually escape frosts altogether once the normal spring season has arrived. The average variation in temperature in favor of the lands lying above the valley floor is from 5 to 6 degrees, due to a marked inversion of the temperature gradient when cold dense air creeps in and lies in stagnant pools underneath the warmer air. Temperatures as low as 23 to 25 degrees on the ground and 32 to 35 degrees fifty feet above have been recorded by special frost investigators.

Because of this frost danger on the valley floor, most of the more recent fruit orchards have tended to migrate up along the detrital slopes where air drainage is

better. Here is located the greatest orchard acreage at the present, although several fine old orchards are still to be found in the low lands. Eternal vigilance against spring frost is the price paid for these orchards, however.

An additional characteristic of the precipitation of this complex climatic region, and one which has played an important part in shaping its economic history, is its variability in amount, monthly and annually. There is a noticeable difference in total precipitation from year to year. In 1907 the heaviest rainfall in the history of the Ashland station occurred, with a total of 28.87 inches. Two years previously the lowest amount was recorded, when but 11.99 inches fell for the entire year. Months likewise show this variability. In January of 1881 a total of 12.29 inches fell, more in one month than in the entire dry year previously mentioned. August, ordinarily a rainless month, may suddenly find itself with 2.71 inches. November may have a trace or it may have 8.10 inches. Such fluctuations mean that the rainfall is not dependable for ordinary types of agriculture. Under natural conditions the Rogue River Valley would be an area of agricultural risk. With this variability of rainfall, together with a low average total and bad seasonal distribution, it is easy to see why the agricultural specialization of the valley has awaited the development of irrigation.

Thus far little has been said about the landscape and the part climate has played in its appearance. Broadly speaking there are three types of native vegetation associations within the area. The Coast Range section is composed of the typical vegetation and forest types of the humid Pacific mountains, including spruce, cedar, and Douglas fir. The Cascade section includes yellow pine, and hemlock in response to the lesser rainfall to the east. The valley proper supports a typically sclerophyllous vegetation in response to the light winter rains and hot dry summers. On northerly slopes where the winter snows remain longer into the summer, and where the rate of evaporation is not so great, coniferous stands mixed with a number of broadleaved species such as oak, ash, maple, aspen, and cottonwood, give rise to definite forest slopes. Southerly exposures may be nearly bare, except for needle grass and fox tail, which mature early and then are yellow and parched the balance of the summer, together with open stands of oak, mistletoe laden, and occasional thickets of madrona, manzanita, or buck brush. These open hardwood patches give rise to a park landscape whose grasses provide excellent forage most of the year under a setting of evergreen oaks and madrona that can scarcely be excelled for landscape charm, strikingly reminiscent of the Mediterranean.

Another feature of the valley which has shaped the landscape and to a large extent the economic adjustments, and which is traceable quite directly to climatic influences, is the soil.

Generally speaking the soils of the Rogue River Valley are prevailingly low in nitrogen content, due to a deficiency of organic matter brought about as a natural floral response to the semi-arid conditions of most parts of the valley. Likewise there is a slight tendency toward alkalinity in some sections, and everywhere there is high percentage of natural lime, more for example, than one finds in the original parent rock. This characteristic is to be expected as the lowland soils of the valley belong to that great subdivision of lime-accumulating soils typical of the arid and semi-arid regions of the west. This means that the soils have not been leached of soluble plant minerals, in fact minerals from the subsoil have been brought to the surface to some extent through capillary action. Such soils are likely to be excessively productive if the natural water deficiency can be overcome, as has been amply accomplished here by irrigation.

Climatic influences over a long period of time have also made possible a reclassification of soils here for purposes of regional anaylsis. The Soil Survey map for Jackson County shows 45 different kinds. Reclassification on a maturital basis, in which climatic influences supercede geologic, reduces the number of generalized soil types to four, with a high degree of correlation in crop distribution. (1) The undifferentiated mountain soils are mostly wasteland, timberlands, or forage lands. (2) The residual-colluvial foothill soils are youthful and still bear a resemblance to the parent rock. These are the dominant orchard lands, with rich soils, good air drainage, and a maximum of sunny slope, ideal conditions for forcing an extensive pear crop. (3) The arid and semi-arid desert soils of the valley floor are post mature in age, representing an older floor of the valley. These soils, known generally as the Agate Desert, represent waste land, abandoned orchard plots, and even abandoned grazing lands in the heart of a valley pressed for agricultural soils and with irrigation canals crossing at intervals. The adverse feature is a lime-bound "B" horizon that forms a hard-pan inimical to drainage, a feature quite directly due to the interplay of an arid climate on a flat soil type, covering a long period of time. (4) The recent flood-plain alluvial soils are found along the rivers and streams. They represent both an overflow hazard and a frost hazard, with the result that they have recently been given over largely to truck crops, forage crops, small fruits and berries.

These observations are somewhat sketchy, but they do indicate some of the features of the natural landscape and the regional economic development pattern of this particular valley, that are largely traceable to the influence of the elements of weather and climate.

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[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

The Bearing of the Post-Paleozoic Sedimentary Record on the Occurrence of Gas in the Rattlesnake Field, Washington[1]

By HAROLD E. CULVER and RALPH L. LUPHER
State College of Washington

In an attempt to locate a large supply of water under artesian pressure for irrigation purposes in the Cold Spring area in 1912 a well was put down into the Columbia basalt series and began to produce natural gas. Since then the flow of gas has been continuous and for the past few years a commercial operation has been serving several towns in the Yakima Valley from gas delivered by some fifteen wells. So long continued a flow of even the modest proportions obtaining here has naturally awakened considerable interest in the source of the gas and the present paper is an attempt to evaluate some of the data which bear on the question.

Gas is taken at approximately the same stratigraphic zone in all wells that have been drilled, although a secondary source has been found in a few wells and gas taken from both. The main zone lies about 700 feet below the surface, the second some four or five hundred feet lower. Both are in porous basalt unassociated with sediments.

Since the gas could not conceivably have originated in the basalt, but must have migrated there from its source, and since further, it seems unlikely that it has migrated downward from the thin sedimentary zone some two hundred feet above the gas producing basalt, the question of what kinds of rock lie concealed beneath the extensive Columbia River

basalts is important in considering the source of the gas in the Rattlesnake Hills. Some of the implications of several possibilities are here presented.

The predominance of metamorphic rocks and associated plutonic rocks along the northern and eastern margins of Columbia Basin does not prove that these rocks immediately underlie the basalts in the central part of the Basin. In the marginal region the pre-basalt surface today shows relief of at least two thousand feet. Westward and southward the basalt increases in thickness and there is no evidence to indicate the amount of relief of the pre-basalt surface. At Union Gap, near Yakima, the test well of the Miocene Petroleum Company shows the presence of some 3,500 feet of basalt below river level, while the adjacent Rattlesnake Hills uplift shows an additional thickness of more than 1,500 feet, giving a total thickness in this region of at least 5,000 feet for the basalt flows.

South and west of this central portion of the Basin the marginal rocks are notably different in character from those on the north and east. Here are both Mesozoic and Tertiary marine beds as well as continental beds whose extensions beneath the basalt are at least as plausible as those of the rocks from the north and east.

Thick sections of marine Mesozoic sedimentary beds are exposed in Central Oregon to within 75 miles of Columbia River. They have been penetrated by the drill near Fossil, Oregon, thus proving their extension about twenty-five miles northward. There seems to be nothing to suggest that they may not have originally extended still farther north, and that they may not now be concealed beneath the thick basalt flows. In addition, it should be noted that the supposedly Cretaceous beds near Fossil have been shown to contain some natural gas. The postulated extension to the Pasco area would certainly provide an adequate source for the gas known to be there.

The distribution of Mesozoic marine sedimentary rocks in the Pacific Northwest reveals some pertinent paleogeographic facts. Upper Triassic marine rocks are extensively exposed in the Wallowa Mountains of northeast Oregon and in central Oregon. It would be a remarkable coincidence if the northern shore line of this marine embayment lay along the present political boundary of Washington.

The central Oregon region was invaded by the sea at least four times during the Jurassic period. Similar and in part contemporaneous invasions are recorded north of the Canadian border, some extending as far east as western Alberta. The Lower Jurassic deposits are known in central Oregon and along the coast of British Columbia, but the faunas are not sufficiently known to establish contemporaneity of sea invasions. During the early Middle Jurassic a sea spread over central Oregon as far east as the Silvies River and at the same time marine waters invaded southern British Columbia and extended eastward to Alberta.[2] Again in the earliest Upper Jurassic came a similar invasion. Faunas of Proplanulitan age have been reported at several places across southern British Columbia and in southwestern Alberta.[3] On the opposite side of the State of Washington Proplanulitan faunas are known in the extensive Mesozoic section of central Oregon and in the Seven Devils region of Idaho.

It would be a strange coincidence if each of these invasions enclosed the State of Washington three sides without advancing upon its borders.

Cretaceous marine beds are known in the Pasayten area of the Cascades and are widely distributed in north central Oregon. Hence it is reasonable to assume that the embayments in which these rocks were deposited may have been connected across the Columbia Basin rather than completely around it.

West of the Cascade Mountains are extensive early Tertiary marine sediments. While these seem to be marginal to continental beds of the same age along the Cascade front their eastward extension in the depressed Columbia Valley area has not been determined. Whether or not there was a marine embayment in the Pasco region during Mesozoic time there seems to be no reason for thinking there may not have been such an embayment during early Tertiary time. Here again, because of the known gas in some of the Tertiary sediments west of the mountains, an extension into the Pasco region might provide adequate source beds for the gas of the Rattlesnake Hills.

This compilation of paleographic data indicates that unique conditions prevailed if post-Paleozoic seas have not entered the central Columbia Basin region.

In the consideration of possible source beds for the gas of the Rattlesnake Hills field it is of course not necessary to confine ourselves to marine beds since gas may presumably be developed in beds of continental origin as well. Northwest of the central Columbia Basin region lies the Roslyn coal field with a thick section of coal-bearing continental sedimentary rocks which are exposed rather widely in Kittitas County and adjacent parts of Chelan and Yakima Counties. The eastern limit of the exposures from the vicinity of Wenatchee southward is fixed by the overlying basalts of the Columbia series. That the basalt covers a considerable thickness of the continental beds is obvious, but it is by no means clear how far east of the present margin of the exposures the beds were originally deposited. In the drilling test made by the Norco Company on Wenatchee Heights, the sandstones of this series are proved to be more than two thousand feet thick, and it is inconceivable that so great an accumulation would have no corresponding eastward extension. In the direction of Rattlesnake Hills an extension of 60 miles from the known outcrops of the sediments would bring them well beneath the uplifted basalts now furnishing the gas of this interesting field. While there is no positive evidence to support such an hypothesis, it is reasonable to entertain the idea that such an extension actually exists. Not only do these coal-bearing beds provide abundant gas but the reported oil seeps in the Wenatchee area are in this Eocene series and hence these strata furnish an additional possible source for the gas of the Rattlesnake field.

One other possibility remains to be considered. This is the presence of interbasalt beds of such character and thickness as to provide both the source and the reservoir rocks for the field. Such beds are a commonplace in the Columbia Basin. The original Ellensburg zone is probably the best known, but others, of even greater thickness are described from all parts of the basin. In fact it is a rare section of the basalts which does not show some trace of sediments which were deposited during intervals between the emission of flows. For the purpose at hand, however, it is better to confine ourselves to the sedimentary zones of large dimensions. Such beds are well known at the head of Grand Coulee, in the Latah area of Spokane County, and farther to the southeast in the Payette region of western Idaho. In the last-named area, particularly, is the occurrence of interest. Here thickness of several thousand feet is reliably reported by drillers over a rather wide area. Of even more importance than their dimensions is their gas content. In several instances the penetration of the gas zone in these beds resulted in the wrecking of drilling rigs. While no commercial gas wells have been developed as yet, the certain occurrence of great quantities of gas under considerable pressure is of especial importance in connection with this study.

It remains to consider what correlation, if any, can be established between the

thick beds of the Payette region and the possible source beds of the Rattlesnake gas. Present drilling operations in the basalt of the Rattlesnake field have penetrated some fifteen hundred feet beneath the surface in this area. This is well below the position of other interbasalt sedimentary sections so far recorded in the Columbia Basin or adjoining areas. If it be assumed that all of these interbasalt sediments were deposited at the same time, or even approximately the same time, it would appear unlikely that any such strata would be found below the zone already penetrated in the Rattlesnake drilling. There is, however, no reason to suspect such contemporaneity in sedimentation over the whole area, and it is plausible to expect interbasalt beds at any stratigraphic position within the whole section. From another point of view, it is also reasonable to consider that a Rattlesnake Hills correlative of the thick Payette sediments lies beneath much greater thickness of basalt than appears in the Idaho section. This point involves consideration of the date of the subsidence of the central part of Columbia Basin, a phase of the subject far out of the scope of this paper. From the foregoing compilation, it is clear that consideration of interbasalt beds as a source of the Rattlesnake field gas is well justified.

The gas of the Rattlesnake field is a fact. The presence of some small amount of oil seems well substantiated also. Hence an attempt to evaluate some of the known features of post-Paleozoic stratigraphy seems desirable so as to provide a starting point for future work. It is not in accord with the purpose of the authors to suggest which of the several possibilities seems, on present data, the most probable. On the contrary, it has been consistently pointed out that there are few data which point directly to any conclusion.

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[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

[2] McLearn, F. H., Some Canadian Jurassic faunas: Roy. Soc. Canada, Trans., 3rd. ser., Vol. 21, pp. 61-73, 1927.

[3] McLearn, F. H., Idem.
Buckman, S. S., Jurassic Ammonoidea. Mesozoic paleontology of Blairmore Region, Alberta: Nat. Mus. Canada, Bull. 58, pp. ...., 1929.

Abstracts of Papers Read Before Geological Section N. W. S. A. December 29-30, 1937[1]

[1]Abstracts of papers presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936.

DISCOVERY OF FOSSIL FISH IN THE LATAH FORMATION

By VERNON E. SCHEID
University of Idaho

The discovery of fish in the Latah formation is announced. Parts of 12 skeletons have been found at a road cut outcrop on the north bank of the Clearwater River, 11½ miles east of Lewiston, Idaho. The skeletons have not yet been determined accurately but are considered to belong to the genus Leuciscus. They indicate that the fish were from 4 to 12 inches long. Scales were also found. Associated with the fish are fossil leaves of cypress, sequoia, sweet gum, sycamore, and red bud trees.

COMPILATION OF MAPS FROM AERIAL PHOTOGRAPHS BY A RADIAL LINE RESECTION METHOD

By JOHN B. MILLER
University of Idaho

A method is given for the construction of maps from aerial photographs by a radial line resection method as outlined by G. S. Druhot.[2] A straight line which represents approximately the course of the

airplane is extended across a series of pictures. This is used to orient pictures as an assembly tracing is made. Working centers of the picture are established successively on the tracing by a method analogous to plane table resection. Points are intersected to bring detail into position.

Information available from pictures is valuable in all mapping work, but is particularly valuable in mapping inaccessible mountainous areas and thickly forested regions.

CURIOUS SURFACE MARKINGS ON BASALT NEAR McCALL, WASHINGTON

By OTIS W. FREEMAN
College of Education, Cheney, Washington

One of the numerous scabland channels that was carved by glacial flood waters in the surface of the Columbia Plateau extends southwestward from Lamont and is followed by the S. P. & S. Railway. Near the railway siding called Macall in eastern Adams County, about 15 miles south of Lamont, are some curious surface markings on basaltic flows exposed in the scabland channel. Apparently these flows were among the last that covered the Columbia Plateau in Washington. Some of the rock surfaces show pahoehoe structures, a characteristic of the younger flows.

On the face and top of a five to ten foot cliff are some curious cracks. These are arranged in fairly good geometric designs, usually polygons. In some of the four to eight sided polygons are two or three similar smaller designs whose sides were parallel to those of the enclosing polygon with lichens partially filling the cracks. The discoverers believed that these designs had been carved by human beings. At first glance the designs do resemble somewhat deep scratches and gougings made by man. However, no rock fragments have been found that might have been left from the work, nor any worn stone tools. Furthermore, the designs are not like Indian rock carvings, as there are no pictures of animals nor of human beings and their activities. The designs generally occur on the smooth surface of lava ellipsoids. It appears to the author that as the uneven surface of the lava quickly cooled the crust became too small for the inside of the mass and so cracked superficially to the depth of ½ inch to one inch. Although weathering has enlarged the cracks and brought the markings out more prominently into relief, the appearance of the rock surface suggests that the cracks dated from the first cooling of the lava. The process would seem to resemble somewhat cracking of the surface of a loaf of French bread. Incidentally, the inside of the lava, as in the bread, is filled with holes from gas bubbles.

A few miles away from this outcrop are three or four dikes of basalt etched out into relief by erosion. The dikes are of basalt that has cooled into columns that lie perpendicular to the walls and which present an appearance somewhat like a pile of wood. Many stone walls were built by early cattlemen in this region for corral purposes. These dikes were thought to be artificial by local residents, but are clearly intrusive. It is impossible to state whether the recent lava flows containing the curious markings emerged from one or more of these dikes or not.

STATE LINE EARTHQUAKE

By BENJ. H. BROWN
Walla Walla, Washington

On July 15, 1936, at 11:05 P. M., an earthquake shock was felt in the region around Milton, Oregon, and Walla Walla, Washington. Many chimneys were broken, several houses moved an inch or two, loose objects and shelf wares were scattered about with some damage. Hundreds of concrete and plastered walls were crecked. One two-story concrete house was restored by making it over into a one-story house. The warden's brick house at the peniten-

tiary has been declared unsafe. Several capstones in the cemeteries were loosened on their bases and slightly rotated. The flow of an artesian well was greatly increased by the shock. The center of the quake seems to have been along an old fault line running west-northwest, through Milton-Freewater and Umapine, Oregon. There also was a secondary line of damage north of the one described extending across the state line into Washington. Occasional aftershocks have been felt during the following months.

The cost of repairing the Milton-Freewater school was $8500. The writer estimates total loss of $100,000.

AN ANALYSIS OF 45 YEARS OF PRECIPITATION AND AIR TEMPERATURES AT MOSCOW, IDAHO

By G. W. HAMMAR
University of Idaho

Analysis of the weather data collected at Moscow shows that the most prevalent precipitation differs significantly from the numerical average. The reason for this is that the average is much affected by a few abnormally wet years. It was found that the most probable precipitation for the summer and fall months, July to November inclusive, is only 4 inches while the numerical average is over 7 inches.

The analysis also shows that Moscow has normally two rainy seasons, one culminating in December and January, and the other having its maximum in April and May.

The distribution of the annual precipitation shows the influence of two factors not yet identified with certainty, one having an annual and the other a semi-annual period.

When the summer, July and August, precipitation is analyzed it is found that the average we receive has been steadily declining during the last 30 years.

The numerically average temperature is very close to the most probably mean temperature for all months of the year.

GEOLOGY OF THE CLARK FORK-SANDPOINT PORPHYRY BELT

By ALFRED L. ANDERSON
University of Idaho

A prominent zone of crustal weakness stretching west-northwest along the north margin of Pend Oreille Lake in north Idaho has localized the intrusion of a group of porphyry dikes and stocks. It appears that some time after the molten magma of the Nelson batholith had solidified, but before the liquid lava of the Columbia River basalt was poured out, great shearing stresses related to major earth movements cracked and fissured the earth's crust along the zone mentioned above. Liquid magma was then injected upward into these openings, probably at the time the Rocky Mountains were being built. This magma failed to reach the surface, but solidified a short distance below as porphyries of different compositions, which have since been exposed as a result of deep-seated erosion. Movement has been recurrent along this zone of weakness, and the famous Hope fault along which the rock masses have been displaced many miles is also aligned along the zone and controlled by the same earth stresses. Mineralization in the Clark Fork district has also been localized along this zone of structural weakness.

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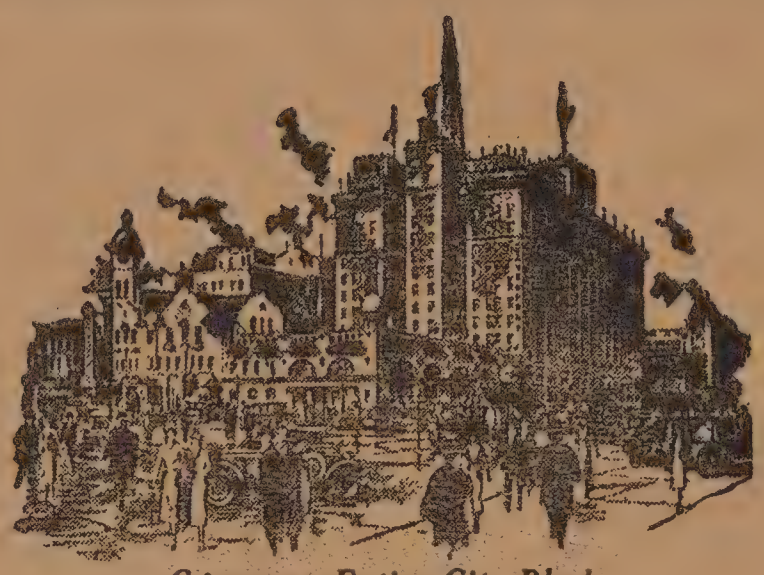

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A Message From the Board of Trustees

ANENT RESEARCH FUNDS

By E. M. Keyser, U. S. Weather Bureau, Chairman Board of Trustees

A check-up on available funds for next year's research programs shows on hand, at present $112.41 from the Howard Flint Memorial Fund. More may be received by the time of the meeting.

There was abandonment of Dr. Klug's project, due to his transfer from the University of Idaho to Minnesota University, and his wish, concurred in by the Executive Board, is not to have the project moved out of the Northwest. He returned unused funds, and the equipment purchased by Association funds is now at Idaho University, available for other research projects. More funds could be used for any of these projects and would be gladly received.

There is a request for funds for a botanical project promising worthwhile results.

Of the two groups of officers of the Northwest Scientific Association, the Council and the Trustees, the record of results achieved, shows the Council has been functioning the most persistently and actively. Annual meetings have been held since the organization some fifteen years ago, numerous scientific papers called forth and published in the official magazine, Northwest Science, and the Association has been well advertised and has a very respectable scientific standing. However, it is only within the last few years the Trustees have shown much actviity along the lines prescribed for them in the constitution. True, they have canvassed the field of a number of sciences for live problems for research and have selected a number of outstanding value as applied to the Northwest.

In 1935 support of research was started in a small way when four members contributed twenty-five dollars each, making possible modest support for three worthy projects. Our affiliation with the American Association for the Advancement of Science now brings an annual fifty dollars for research. This and other personal contributions continued this support and added another project, during 1937.

The passing of Howard R. Flint inspired more than one hundred of his former associates to launch in his honor a Research Memorial fund, which now with dividends is well over $1100, and which will, it is hoped, produce a permanent annual amount. Mrs. Elizabeth Flint, his widow, despite her supporting a family of growing children, contributed, thus far, $25 a year to this fund, on his birthday. This might well be a challenge to other members to help the Memorial grow.

At a recent meeting the Council voted to accept voluntary contributions from members at the time of payment of annual dues. Dues are one dollar per year including subscription to Northwest Science! Either the Flint Memorial Fund or the Research Fund may be designated by donors. Funds are acceptable from any legitimate source.

CONTINGENCIES, A SOURCE OF FUNDS

A number of active members of the Association have been invited to assign a portion of some insurance policy, or a residuary part of their estate, when and if not needed by their dependents. It develops that there is involved in this plan an inherent loyalty to precedent of leaving the estate or insurance policies descend to relatives, though not dependent, and most of those solicited are hesitating to make definite commitments of parts of policies or estates, once they and their dependents are absolutely through with them. Here is an opportunity for the real lover of research to weigh a definite and possibly substantial lift to the Research program against the precedent of legal, though not dependent heirs, who might not be more than remotely benefitted. Assignments of some shares of insurance policies by contingent clause and of parts of estates by codicil to will have begun. While donations of a direct character to the research fund are always wanted and invited, many who cannot now give in that way are asked to consider having their wishes go into effect after their dependent loved ones and themselves have passed on.

DEC 1 0 1937

Resolutions Adopted by the Forestry Section, Northwest Scientific Association, Spokane, Washington, December 30, 1936

1.

WHEREAS, few sciences, either fundamental or applied, demand of their practitioners so wide an acquaintance with the various fields of human endeavor; and

WHEREAS, it is the feeling of employers of young professional foresters that the vocational aspect of their work be obtained during a training period immediately after gaining employment rather than in the classroom;

THEREFORE, BE IT RESOLVED, that the forestry section of the Northwest Scientific Association strongly recommends that the western forest schools give the broadest fundamental training, both in the physical sciences and the humanities, that is compatible with the facilities and time available in their respective schools.

2.

WHEREAS, with the increase of knowledge and the resulting specialization in the broad field of forestry, it is becoming increasingly evident that a broader fundamental training is needed in the undergraduate preparation of prospective foresters; and

WHEREAS, the Society of American Foresters has recently suggested the setting up of minimum course requirements as one qualification for membership in the junior grade that may seriously restrict the forest schools in giving prospective foresters the fundamental training needed for the broad field of forestry;

THEREFORE, BE IT RESOLVED, that the forestry section of the Northwest Scientific Association strongly urges the Council of the Society of American Foresters to give careful thought before adopting any membership requirement for the junior grade that may hamper or restrict the forest schools in their attempt to prepare men for the profession of forestry.

3.

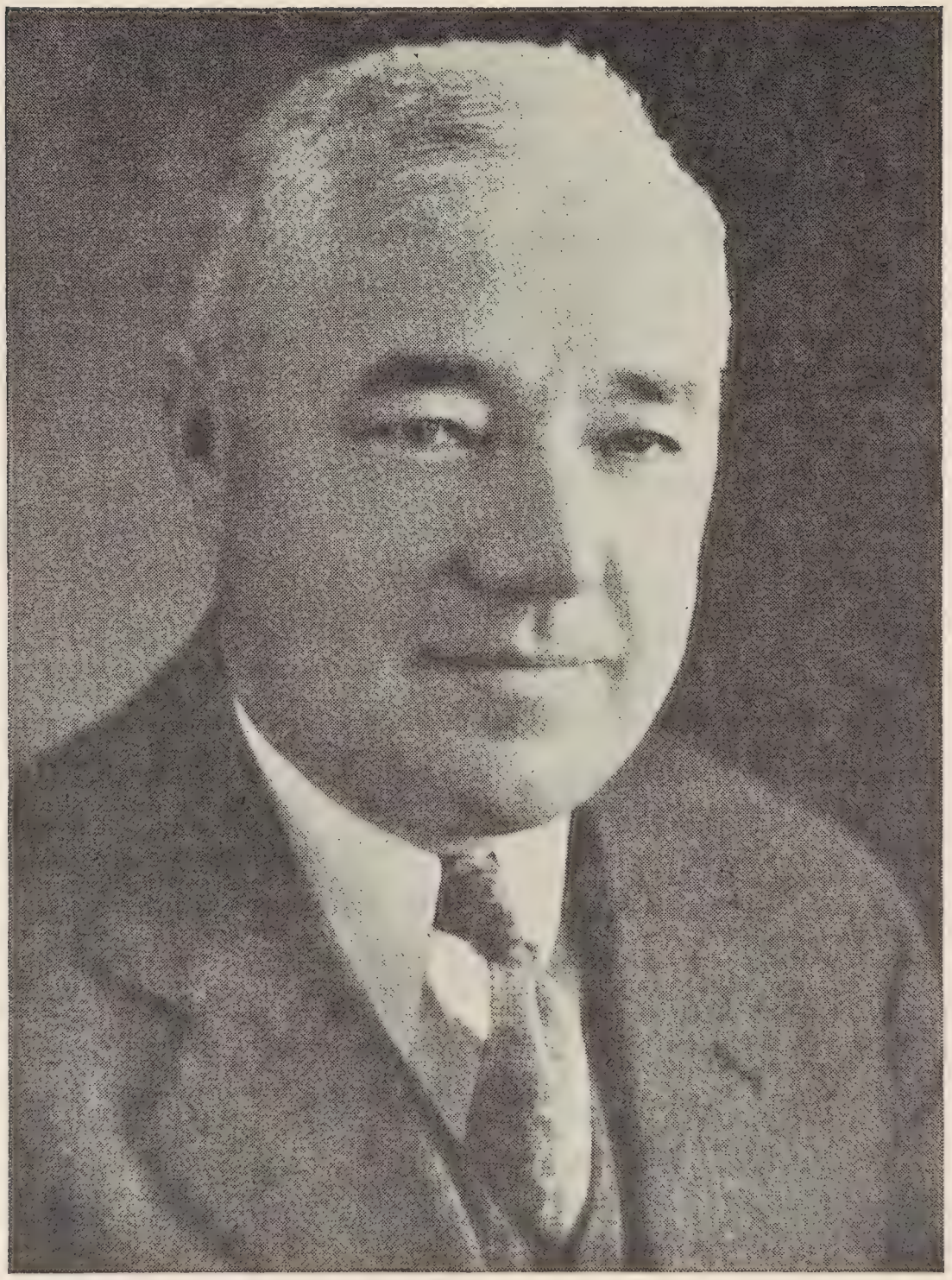
WHEREAS, Federal organizations selecting for employment young professional foresters and range management men from the Civil Service eligible lists have for a number of years criticized the inadequacy of training of such men; and

WHEREAS, these young men to place their names on the eligible list must pass an examination, the questions for which are made up by the same organizations who have been most severe in theri criticism;

THEREFORE, BE IT RESOLVED, that a committee from the Federal organizations and a committee from the forest schools do their best to bring about harmony in the needs of the Federal organizations and the methods used to fulfill these needs, the two committees to unite their efforts in attempting to convince the Civil Service Commission of the merit of their suggested plan.

Secretary-Treasurer's Statement

A good general program is being arranged for the meeting of the Northwest Scientific Association. Dean Edward C. Johnson, of the College of Agriculture, Washington State College, who has just returned from scientific studies in Europe, will lecture at the first general session. Dr. H. K. Benson, Head of the Department of Chemistry and Chemical Engineering at the University of Washington, will speak at one of the general meetings, probably at the annual dinner, on "Application of Chemicals to Industry." He will also speak at another meeting on "A Chemurgic Program for the Pacific Northwest." (Continued on page 82.)



Dean J. A. Kostalek

The sudden passing of John Anton Kostalek came as an appalling shock to his many friends. A lover of sports, his death followed a heart attack during one of the thrilling periods of the Idaho Homecoming football contest, September 25, 1937.

Born at Prague, Czecho-Slovakia, September 13, 1885, he came to the United States with his parents when he was two years old. The family located in Wisconsin and much of his early life was spent in Milwaukee. Graduated from the University of Wisconsin with an A. B. degree in 1907, he entered the graduate school and received his M. A. degree a year later.

He enrolled in the University of Illinois where he was associated with such scientists as Nef, Noyes, and Washburn. The Ph. D. degree was awarded to him in 1910. His major interest centered in organic chemistry and his first published paper dealt with the nitrogeneous derivatives of malonic ester. The next year was spent in the employ of the B. F. Goodrich Rubber Company where he served as a research chemist.

Always interested in academic work, he decided to enter the teaching profession and came to the University of Idaho in 1911 as instructor of organic chemistry. In 1912 he was promoted to assistant professor and in 1915 became an associate professor. He left the campus during the World War to serve his country as a member of the Chemical Warfare Service in the Research Division. As visiting professor Dr. Kostalek headed the division of analytical and organic chemistry at North

Dakota Agricultural College during 1919-20.

In the fall of 1920 he returned to Idaho as Professor of Organic Chemistry, and in 1931 was appointed Dean of the College of Letters and Science and the Director of the Pre-Medical and Pre-nursing curricula. These positions he held until his death.

At Twin Falls, Idaho, August 23, 1916, he was married to Helen Pitcairn, who survives him. To them were born two children, Mary Elizabeth, a student in the University of Oregon Medical School, and Katharine, a senior in the Moscow High School.

The diversity of his interests is shown by the large and varied group of organizations in which he held membership. Dean Kostalek became a member of the Northwest Scientific Association at the time of its inception. He held the position of president in 1929 and had served on the Board of Trustees for a number of years. Other organizations to which he belonged included the American Chemical Society, The American Association of University Professors, and The Association for the Advancement of Science.

His scholastic and scientific ability were recognized by his election to Phi Beta Kappa and Sigma Xi during his college career. He served as president of the Idaho Chapter of each of these organizations in later days. He was also a member of Phi Lambda Upsilon, honorary chemical fraternity, and Delta Tau Delta, social fraternity.

In order to find relaxation from his many duties Dr. Kostalek spent a part of his leisure time collecting old books and manuscripts. One of his more interesting treasures was the first reprint of the first edition of the plays of William Shakespeare. His particular hobby was the collection of source material of Northwest History.

Dean Kostalek was known as an outstanding teacher and administrator. While full of sympathy for the student who found the going difficult, one of his major interests was in elevating the standards of attainment for the better students. Under his guidance as director of the Pre-medical and Pre-nursing curricula, these divisions of the University achieved outstanding success. He envisaged a university of the future which would combine certain advantages of the English and European systems with better features of our present academic methods. Even above his administrative success and academic visions, those who knew him best appreciated the greatness of his character, his absolute mental honesty, courage, friendliness, intellectual brilliance, broad interests, and above all his love of his family and abiding loyalty to his friends.

In the passing of Dean Kostalek the academic and scientific professions have suffered a loss which is felt beyond the confines of the campus where his best years were spent.

(Continued from page 80.)

It is earnestly hoped that there will be a record-breaking attendance at the annual meeting December 28th and 29th at the Davenport Hotel.

Some scientific motion pictures, selected by the retiring president, J. W. Hungate, will also be presented at the annual dinner. Section programs are: Bacteria and Public Health; Botany-Zoology; Chemistry-Mathematics; Education-Psychology; Engineering; Forestry; Geology-Geography; Social Science; Soil Science. The Soil Science is a new section, and the Engineering section is being revived this year after a one-year lay-off.

The annual dinner will be held Tuesday night, December 28th. On Wednesday, December 29th, there will be a combined luncheon of the Associated Engineers of Spokane and the Northwest Scientific Association. The Sigma Xi breakfast will be held on the morning of December 29th, provided the scientists who are members of that organization wish to hold the same.

OTIS W. FREEMAN,

The Education of a Forester in the Sciences and Arts

By GEORGE FINLAY SIMMONS

President, University of Montana

I am asked to present myself as a target in a very unequal combat. As one who is not a forester but who has spent his life in other fields of education, I have been asked to present some criticisms and suggestions of what the education of a forester should be in the field of arts and sciences. Fortunately there has been little disagreement in the past and there is little disagreement at the present time among even the professional foresters as to the best procedures. The only question that remains is the practical one of whether or not members of the forestry profession will hold steadily to their beliefs under constant pressure from impatient undergraduates and their parents to turn out so-called foresters with a minimum of training in order taht they may quicker enter into their life's work. In other words, can a student who enters academic training in forestry be convinced that a long-time program for his future development on a high plane with training as a genuine professional man comparable to the lawyer, doctor, engineer, with a broad knowledge of the world and its problems, is far better than training on a sub-professional and semi-vocational level for minor jobs that will never rate much above a routine or labor basis.

The deliberations of a Committee on Forest Education as far back as 1911 set forth certain matters for emphasis. The committee agreed that there was a "definite body of knowledge and educational experience that must be possessed by every qualified forester." In a discussion of what should be contained in a curriculum prescribed to meet this objective, special emphasis was placed on general educational subjects, especially history, economics, English, and foreign languages, as well as botany, geology, and similar scientific subjects. The committee concluded that to train specialists along different lines in a four-year curriculum was an impossibility, and that such specialization should be attained in advanced work. The committee members agreed that in undergraduate work a student should be given well-balanced instruction in forestry proper, "Perhaps with a little more emphasis on either silvicultural work, or forest engineering, chiefly lumbering. Any tendency, however, to increase the training along any of these speciailzed lines within the four-year course must necessarily be done at the expense of the other subjects, or else the number of years required for this training must be increased. The scope of the courses considered here has in view a well-balanced professional school which does not aim at great specialization in any one of these three lines of work, but attempts to give a general knowledge of the principles which underlie the entire field of the forester's activities, leaving the acquisition of special knowledge to be gained by the students in actual business life, or after graduation from the forest schools, or by special study."

Gifford Pinchot, who as Chief of the U. S. Forest Service served on the committee of 1911, in his treatise on "The Training of a Forester," as early as 1914 pointed out that a number of forest schools do not prepare men for professional work in forestry. Of those which do

(This paper was delivered before the Forestry Section of the Northwest Scientific Association in meeting at Spokane, December 30, 1936. A companion paper, "The Education of a Forester in the Technique of Forestry," was delivered by Walter Mulford, Head of the Division of Forestry, University of California. Due to Dean Mulford's illness during the past summer, this paper could not be revised, as delivered, ready for publication.

give such training on a professional level, the larger part give a four-year undergraduate course while the few remaining give the most worth-while course of all on a graduate basis and demand possession of a college degree before a student is admitted for work in the professional school.

"The subjects required for entrance to a graduate forest school," wrote Pinchot, "should include at least one full year in college botany, covering the general morphology, histology, and physiology of plants, one course each in geology, physics, inorganic chemistry, zoology, and economics, with mathematics through trigonometry, and a reading knowledge of French or German. Some acquaintance with mechanical drawing is also desirable but not absolutely necessary. Other courses which are extremely desirable, if not altogether essential, are mineralogy, meteorology, mechanics, physical geography, organic chemistry, and possibly calculus, which may be of use in timber physics."

He applauded the practice of a couple of forest schools in beginning the training of their new students in July out in the forests instead of in a classroom in October, resulting in increased vividness and reality of all the courses that follow the work in the woods. All courses should include outdoor instruction, winter and summer, and "the last term of the senior year may well be spent wholly in the woods, where the students can be trained in the management of logging operations and milling, and can get their final practice work in surveying and mapping, in preparing forest working plans, estimating timber, laying out roads and trails, making plans for lumber operation, and other similar practical work."

Pinchot, commenting on the fact that regular courses in such a graduate forest school cover a two-year period, says that "They should fit a student for nearly every phase of professional work in forestry, and should give him a sound preparation not merely for practical work in the woods, but also for the broader work of forest organization in the Government Service in the United States and in the Philippines, and in the service of the States; for handling large tracts of private forest lands; for expert work in the employ of lumbermen and other forest owners; for public speaking and writing; for teaching; and for scientific research."

During the last three decades the field of forestry has broadened so rapidly, and the field of employment of foresters has opened up so quickly that it has been difficult for schools of forestry to keep their curricula up to date. Furthermore, the accumulation of knowledge in the field of forestry, and of the applications of such knowledge, has had the major part of its accretion during the last thirty years. Just as in other scientific fields, instructors have found it very difficult to cover the ground within a specialized section of course within the time allotted for such course in the curriculum, hence they have either expanded the time of a course or have added new courses. The result has been to weaken the fundamental work, to add more technical and semi-vocational courses to the curriculum, and to depart more and more from the prescibed course laid down in 1911.

Following the earlier conferences, one was called by the Yale School of Forestry in 1920, and this was followed by many months of detailed work on the part of different committees, whose reports were published in 1922. These reports laid emphasis on three types of training in forestry. The first was a well-planned four-year scientific and technical course, in which was given a minimum of work in the humanities, with English confined to required composition, and with public speaking as a possible elective; and, of course, such a crowded curriculum made no mention of history or modern language or of any other studies of a general cultural nature. The second was a five-year

curriculum which laid special emphasis on the humanities and cultural subjects as a foundation for forestry as a real profession. Third, specialization was provided for through graduate work and was frowned upon as a part of an undergraduate curriculum.

In 1932 the Yale University Press published a very fine book on "Forest Education" by Dean Henry S. Graves of the Yale School of Forestry and Professor Cedric H. Guise of the Department of Forestry at Cornell. This book points out that with changing economic conditions, "the practice of forestry will become progressively more exacting and the need for an adequate professional preparation for the more responsible positions will become more emphasized." The authors repeatedly emphasized the point that the forest schools have not followed the original recommendations of the committees of 1911 and 1920. They say further that "a professional education in forestry, if it is to be anywhere near complete, must include four phases of educational experience: First, general education; second, pretechnical studies; third, technical studies; and fourth, applied field work. If the forest school performs its functions effectively, the graduate of a four-year course will have a reasonably good groundwork in each of these categories. But he is not a trained forester in the professional sense."

Of course, neither the four-year graduate himself nor his employer will recognize the defects and limitations of a four year course. Actually, as time goes along, both the recent graduate and the employer will conclude that the forest school has failed to provide a training for actual problems and conditions. Such an attitude results in pressure to make the course more practical, to include more semi-vocational courses of a specialized character, and to weaken the theoretical courses. If the immediate objective of forest school education is to prepare a man for the work he is going to do as soon as he enters his field of service, then such training could best be handled as a form of vocational or manual forestry training or as a type of industrial apprenticeship; such individuals have no real need for attending a professional school of forestry. Any school of forestry which fits its curriculum merely to such needs is lowering the profession of forestry to a vocation or trade. In any profession, such as the fields of law, medicine, engineering, architecture, or teaching, we do not expect a high grade of performance for several years after completion of a college course. A young Doctor of Medicine must serve an interneship before he is even permitted to practice. A young lawyer is frequently employed as a law clerk by more competent lawyers and there serves an apprenticeship. No college or university of any standing would even consider employing a recent graduate of a four-year course to teach in any field of knowledge. Even where a young Doctor of Philosophy is employed for instructional purposes, he is frequently assigned to laboratory courses or routine recitation classes as a sort of glorified student assistant. It is usually several years before such an individual is turned loose on his own responsibility to organize and teach sound courses. How, then, can employers of recent graduates of schools of forestry expect such young men to be anything more than immature and untried?

The most constant criticism which we hear of the training of such young foresters is the lack of thoroughness in fundamentals. With so much time spent on injecting a sort of apprenticeship into the period allowed for education, with the overloading of students with advanced work which they are unable to grasp because of their defective basic education, there is real reason why the student suffers mental indigestion and why his training degenerates into a type of hasty fact cramming over too wide a range of sub-

ject matter with the thought in mind that he should have at least a conversational and general examination knowledge of the various fields of forestry. If at any time such students, or graduate foresters themselves in later years, feel that a large part of the basic and theoretical work in school is of little value, then that is probably because the courses were not well organized or not well taught. Another source of difficulty for the student has been the very spotty instruction given students in some high schools, necessitating the spending of a considerable amount of time in college, especially during the freshman year, in repeating such instruction in elementary college courses which should have been given the student in high school. This condition is true even in the more advanced courses in college, where an instructor frequently has to spend a quarter of his time in explaining background and fundamentals to students who have neither the learning nor the mentality to grasp the difficult problems in an advanced technical course, if such course were set at its proper level and contained its fullest possible material.

The conclusion of these leaders in the field is that five years are desirable for a full professional training in forestry. I should say that five years is the absolute minimum. If one considers the somewhat comparable fields of law and medicine, one learns some rather interesting facts. . . . . All the larger medical schools have gradually worked toward the requirement of four years of pre-medical work. It is interesting to note in a report made of the more prominent medical schools in the country, that those students most successful as medical students and as successful practitioners were the ones who had entered medical school with a general Bachelor of Arts degree. Somewhat less successful were the students who had taken a four-year pre-medical course; part of this pre-medical work pretended to cover pre-technical courses such as bacteriology, biochemistry, and even comparative anatomy and embryology. Where such recent pre-medical students come from smaller universities with credits in such courses, they are made to repeat such work in the larger institutions where the courses are taught on a much higher plane; nearly every medical school prefers to give its own pre-technical courses, dove-tailed into the truly technical courses. And the least successful of all the medical students, both during college and in after life, were those who had entered medical school with only two years of pre-medical training. The moral of this is obvious, that it is no solution of professional training to curtail fundamentals. . . .

As a result of a questionnaire sent out to the graduates of forest schools, and studied by Professors Graves and Guise, nearly all of such graduates urged more fundamental work in economics, the humanities, natural sciences, and a general increase in the amount of education. The younger men felt a need of more practical knowledge for their immediate work, while in the main the older and more successful men urged greater attention to developing the intellectual powers of students, stimulating their broad interest in human affairs and in the arts and sciences of civilization, with a better command of the Engilsh language in speaking and writing. . . . . We might here mention again the fact that so many Government bureaus and industrial organizations have elevated to high executive positions lawyers who are entitled to append B. A. and LL. B. after their names. In fact, one such man whom I recall at the present moment took his bachelor's and master's degrees in arts, as well as the bachelor's and master's degrees in law.

From a practical standpoint, two years Certainly many of the outstanding leaders in forestry completed a college course in the arts and sciences before studying forestry.

of arts and science work is about all that a forest school could demand at the present time. The curriculum of such two years of general education should correspond roughly to that of the modern junior college, yet with a somewhat greater amount of laboratory science than general science. Graves and Guise say that "the deficiencies in general education at the forest schools may be corrected in part by the inclusion of certain courses in the humanities and social sciences." These authors follow with a rather careful analysis of the preparatory studies, covering approximately the first two yeas and including basic work in science, mathematics, economics, and humanistic subjects. Such general courses would naturally include a survey of the social sciences and a survey of the humanities, required composition, mathematics, and basic laboratory courses in botany, chemistry, physics, zoology, and geology.

The pretechnical group of studies, distributed through the second two-year period, would include special work in science, mathematics, and elementary education immediately introductory to technical studies. Here we should have to include the special courses in plant physiology, plant ecology, forest mathematics, silvics, dendrology, and similar courses. The third group of courses would be those strictly technical and professional in character and scope. These would be worked into the last three years of the five-year curriculum.

The general result of this arrangement, which is that being adopted more and more by the leading schools of forestry, is to require two years of pre-forestry, two years of general forestry, followed by a year of specialization, and a ten-weeks practical course in a camp and on inspection trips where part of the apprentice training is actually given to the men before they are awarded a degree.

During this fifth year of training a student may elect minor emphasis on any one of a series of subjects minor to his general forestry training. Such a series of specializations frequently include the following:

(1) Silviculture, where the emphasis is laid on the planting and growing of trees and tree crops. Students interested in such work might take as a sub-minor work in genetics with an introduction to population problems and statistical methods.

(2) Wood utilization, with an emphasis on logging or manufacture; this general subject of harvesting tree crops is classified by some schools as timber management.

(3) Wood utilization from the standpoint of wood technology, which naturally requires chemistry as a sub-minor.

(4) Range management or grazing, for which botanical taxonomy and further work in plant and animal ecology are almost essential.

(5) Plant pathology, which would require more botany than is necessary in a general training for forestry.

(6) Wild life management, which naturally calls for zoology as a sub-minor, with some work in genetics and population problems.

(7) Forest entomology, with zoology as a sub-minor.

(8) Forest recreation.

(9) Meteorology, which requires further work in physics.

(10) Erosion, where a better knowledge of soils and of plant ecology certainly proves valuable.

Even with emphasis on these minor fields of endeavor, no student of such a five-year curriculum can possibly think of himself as a specialist. All fields of knowledge have grown so rapidly that today, unless a man has at least a Master's degree or has earned a Doctor of Philosophy degree, he has not had sufficient specialization in his own field to know how to attack and carry through a highly complex problem dealing perhaps

with several allied fields. The actual practice of forestry requires the employment of many supplementary professions and trades, and the training of a forester, with specialization in a minor field, cannot pretend to prepare a man for work that is best done by a professional botanist, chemist, engineer, zoologist, lawyer, economist.

For instance, in the development of our curricula at Montana State University, we are offering a minor emphasis in our School of Forestry on wild life management, including a major emphasis on forestry and a minor amount of work in zoology. Such work includes general and elementary zoology, comparative anatomy, animal ecology, and a brief amount of work in parasitology and advanced vertebrate zooolgy. It is obviously impossible in such a brief amount of work to include the more interesting and recent remarkable advances in experimental zoology, since such a student in wild life management will not have had the fundamentals necessary to understand much of what is given only in post-graduate courses in the larger technical schools of zoology. With this thought in mind our Department of Zoology is offering a B. A. degree in Zoology, with a major in wild life technology. This course includes added work in both botany and zoology, with courses in biological literature, aquatic biology, genetics, and its allied fields of statistics and population problems, and evolution. At the same time it emphasizes the need for further chemistry, for general bacteriology, general histology, and scientific German or French. . . . . It is obvious that if a student is going to consider the results of the highly complicated field of genetics, of how to cross-breed varieties, select and inbreed for desirable traits, and establish new types of plants and animals, he must have more than a passing knowledge of genetics. If he is further going to consider the effect of mixing populations, of transplanting to new geographical regions varieties from other sections of the country or the world, he must understand the principles of population equilibrium, together with a working knowledge of statistical methods, so that when he makes series of measurements he can determine ranges of variation and apply the usual tests to determine significance. There are very few undergraduates on any campus who are qualified to delve into the question of statistical comparisons such as are made by use of the coefficient of correlation. It is only recently that even the technical experts of the U. S. Forest Service have learned the great need for these methods, largely developed in the field of biometry in England years ago and more recently advanced in England by Professor R. A. Fisher of Rothamsted and in America by Dr. Sewall Wright at the University of Chicago.

With the recent rapid development of industrial methods resulting from technical advances in chemistry, it is obvious that a student recently graduated from even a five-year course in forestry, who has had only one year of chemistry, will not be able to do major work in flotation oils, such as the pine oils that are used in the smelters at Anaconda, Montana, for the removal of copper from ores. In the field of wild life management the Forest Service may very well have need of the services of a biochemist for the extration of reproductive hormones for use in a series of animal rapidly approaching extinction. In such a case it is obvious that only a man with a great deal of zoological training will know anything about the field of the biology of sex or the physiology of reproduction, since such subjects are taught only in graduate schools of zoology in about six great universities.

Again, from the standpoint of maintaining a high level of professional training, with good sound preparation for intellectual work in a difficult field, I wish to

Analysis of the Earthquake Problem in Western United States

By FRANKLIN P. ULRICH
U. S. Coast and Geodetic Survey

One of the most important purposes of scientific research in seismology is to break down that attitude of fatalism or false optimism which seems so prevalent concerning earthquakes. Without doubt, there has been in the past some justification for the attitude of fatalism due to the fact that the average annual death toll from earthquakes is estimated to be about 30,000. Let us consider only a few reasons for this pessimistic attitude. Japan has always been one of the leading nations in carrying on earthquake research, and yet in 1923 an earthquake there killed 100,000 and injured an equal number. It is true that some progress has been made since that time, but we have only a Benevolent and Divine Providence to thank, that in 1933 the Long Beach earthquake was not one of the world's major calamities. In fact, in this country we have been so fortunate at the times of our earthquakes that we just take for granted that earthquakes will always be considerate enough to occur at a time when loss of life and property damage would be a minimum. This is no idle statement, as some short-sighted engineers (and we can be thankful that the number is small) use this particular point as an argument against earthquake resistant construction.

We know no reason why the Long Beach earthquake did not occur two hours earlier and when the public schools were in session. An examination of the public schools after the quake showed that had the earthquake occurred two hours earlier, the death toll would have run into thousands. Carrying this thought another step, we come down to the Helena earthquakes of last year. The collapse of the new high school there showed that some real serious thinking has to be done on this problem. We cannot afford to continue, as we have done in the past, to rebuild along the same old lines and hope that the old mistaken adage, "Lightning never strikes twice in the same place," might be applied to earthquakes.

For economic reasons we have strongly stressed the importance of earthquakes in California, but from a scientific viewpoint we may have over-emphasized the California quakes and under-estimated the earthquake problem in Nevada, as well as in the Northwestern part of the United States. The two earthquakes in Western Montana, occurring at an interval of ten years, have focused attention on two particular points—first, the interval between destructive shocks in any particular region, and secondly, the possibility of additional shocks in the entire Northwest. It would be impossible in a short paper to go into a lengthy discussion of the cause of earthquakes, but it is generally conceded that the majority of earthquakes are of tectonic origin.

Mountain formation and earthquakes,

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emphasize the necessity for at least two years of general academic training, two years of general training in forestry with as little of the vocational and apprentice aspects of the work as possible, and a year of minor specialization which should not lead an individual to believe that he is qualified in this day of rapidly advancing technical fields to compete with real specialists in biological, physical, or social sciences. In forestry such true specialization can only be had by post-graduate work in a school equipped, financed, and staffed to do advanced work on a high plane.

in general, appear to be closely related. These natural processes are still going on and there has been no material change in geological conditions in recent years. Hence, we can reasonably expect about the same number of earthquakes in the immediate future as we have had in the immediate past. We have a fairly good history of recent seismic activity in California and Western Nevada. Since 1769 we have a record of 43 destructive earthquakes in this region. Perhaps many more occurred as we know that 39 of these destructive earthquakes occurred in the past 100 years. These shocks were equal or greater in intensity than the Long Beach and Santa Barbara shocks. A complete history of earthquake activity in the Northwest has never been compiled, so we cannot state the exact number of quakes occurring in this region. However, Donald C. Bradford, in "Seismic History of the Western Washington Territory," lists 20 shocks in that region from 1864 to 1932 and which were classified as being sereve or heavy. Since 1925 the Coast and Geodetic Survey has been charged with the duty of making seismological investigations in the United States, and one of the important parts of the program is to maintain a complete history of seismic actviity. From 1925 to1936 we have record of 29 destructive or near-destructive earthquakes occurring in the Pacific Coast and Western Mountain States. These are listed as follows:

The Coast and Geodetic Survey has been responsible for seismological in-

Year	Day	Intensity, Rossi-Forel	Location of Epicenter
1925	June 27	IX	Three Forks, Montana.
1925	June 29	IX-X	Santa Barbara, California
1926	Oct. 22	VIII	Off Monterey Bay, Cal. (3 shocks)
1927	Jan. 1	VIII-IX	Imperial Valley, California
1927	Aug. 20	VIII	Humboldt Bay, California
1927	Nov. 4	IX-X	West Coast, Santa Barbara County, Cal.
1928	June 3	VIII	Weaverville, California
1929	July 8	VIII	Whittier, California
1930	Feb. 25	VIII	Imperial Valley, California
1930	March 1	VIII	Imperial Valley, California
1930	Aug. 30	VIII	Offshore, 8 mi. W. of Santa Monica, Cal.
1930	Sept. 22	VIII	Humboldt Bay, California
1931	Sept. 9	VII-VIII	Off Cape Mendocino, California
1932	June 6	VIII+	Humboldt County, California
1932	Dec. 20	X	Western Nevada
1933	March 10	IX	Long Beach, California
1933	May 16	VIII	Niles, California
1933	June 25	VIII	Wasbusha, Nevada
1933	Oct. 2	VI	Long Beach, California
1934	Jan. 30	VII-IX	Western Nevada
1934	March 12	VIII	Northern Utah
1934	June 7	IX	Parkfield, California
1934	July 7	VI	Off Oregon Coast
1934	Dec. 30	VII-IX)	(Imperial Valley, California, and
1934	Dec. 31	VII-X)	(Mexico
1935	Oct. 18 & 31	VIII-IX	Helena, Montana
1936	June 3	VI	Off Oregon Coast
1936	July 15	VIII	South of Walla Walla, Washington

vestigations in the United States for the past 11 years. It is felt that considerable progress has been made during that time and it might be well to consider what has been accomplished and also what remains to be done. As previously mentioned, a sesmological history of the United States was one of the first projects undertaken. This has been completed, with the exception of a satisfactory catalog for the Pacific Northwest States.

Although the Coast and Geodetic Survey had been operating seismographs since about 1900, at the time of transferring the work to this Bureau in 1925, many of the instruments were obsolete and the records were not very dependable, nor did they give a satisfactory degree of accuracy. The second task was naturally to bring up to date the instrumental equipment of the Bureau and to encourage the establishment of additional seismological stations in districts which were not adequately covered. At the present time the instrumental equipment of the Bureau is in good shape and the distribution of instruments in the United States, on the whole, is fairly satisfactory except in a few districts and for special work in certain areas. The establishing of seismological instruments in the Northwest has perhaps lagged behind the rest of the country. This was no oubt due to the infrequency of earthquakes in this area. However, the two earthquakes in Montana and the Walla Walla earthquake during the past year have changed the picture. With two sensitive seismographs and four strongmotion seismographs now in operation in Montana, that State is fairly well covered. However, the Pacific Northwest ---that is, Washington, Idaho and Oregon, is not at present adequately covered to give us accurate detailed information. There is need for both the sensitive and strong-motion seismographs in this region.

The purpose of the sensitive instrument is to give dependable information on frequency and location of al earthquake shocks. Information of this kind, especially for local earthquakes, is essential to the insurance companies in fixing an equitable insurance rate and to the engineer who must have accurate data in order to design enginering projects for the development of the country. From the distant earthquakes, the sensitive seismographs provide us with a considerable amount of fundamental scientific data.

The purpose of the strong-motion instrument is to give accurate data concerning the forces set up by earthquake, the periods of oscillation, the amplitude of vibration and the duration of the shock right at the center of the earthquake or as near as possible to the center. With such information, engineers and architects have some idea of the forces against which they have to design their structures. Unless they have such information they cannot design the most economical earthquake-resistant structures. As the cost of making a structure earthquake-resistant increases the cost of that structure only from four to ten percent, as stated by the Board of Fire Underwriters of the Pacific, it is quite certain that eventually all public buildings or any buildings housing a large number of persons will have to be made to withstand earthquakes.

At the present time the Coast and Geodetic Survey operates or cooperates in the operation of 55 strong-motion instruments—50 in California, 4 in Montana and one in Nevada.

Another important phase of our work is what we call the Questionnaire Program. Thousands of cooperators throughout the United States are furnished questionnaire cards upon which to report felt earthquakes. From these cards we obtain much valuable information on the intensity of shocks at various places and the area over which damage has occurred. This program has been operating fairly well for some time. Because of the increasing importance of this work, especially here in the West, a plan is under consideration

at the present time which will provide for a more detailed coverage after each earthquake.

The matter of earthquake prediction is one that often gives certain groups a great deal of worry. From an engineering viewpoint, we should assume that we can expect earthquakes and should build our structures accordingly. When that is done, the major part of our fear and worry will have been overcome. Earthquake prediction is so unreliable in this country that at present it is of little or no value. In a few cases it has been shown in Japan that tilting of the ground preceded an earthquake and this afforded an approximate prediction prior to its arrival. This method is based upon data derived from accurate measurements of earth tilts. Such effects can be more readily observed in Japan where the earth tilts have a much greater amplitude of motion as well as a much faster cycle. At the University of California we have four tiltmeters to measure these minute earth tilts. If we are to obtain definite information from these tiltmeters, it will only be after years of observations which will include several fairly sharp earthquake shocks. However, it is possible to perceive where an abnormal meteorological condition, such as an unusual high or low barometer reading or a severe storm might act as a trigger force to set off an earthquake which is about to happen anyway.

Another branch of seismology which has erceived considerable attention in California covers the purely engineering phases of the problem. Considerable work has been done in studying vibrations of buildings and structures. Information on vibration periods of hundreds of buildings has been obtained. In case of an earthquake, this information will be valuable in several ways. First, a study will be made to see if buildings of any certain period of oscillation suffered more or less damage than buildings of other periods. Secondly, if, after a severe earthquake, the period of a building is redetermined, then the relative change in the building period will be one of the best means of determining the extent of structural damage in that building. In a few cases buildings have been studied when subjected to artificial vibrations simulating an earthquake. Efforts are being made to determine periods of ground vibration in order to check up the effect of resonance between ground and structure.

In checking over accomplishments during the past few yeasr, mention should be made of the study of masonry building damage caused by the Long Beach earthquake. A considerable amount of study has been applied to checking over available seismological records in Southern California to determine if dominant ground periods are present during earthquakes. Naturally, in work of this nature, new methods and new instruments have to be developed. The development and actual construction of these instruments has been a large problem. As the program continues there develops a need for additional instruments and instruments of a different type to supply other needed information. These problems have been met and solved both in California and in Washington.

A last phase which should be mentioned in the growing interest of seismology is the interest being manifested by a number of amateurs who take up seismology as a hobby and build amateur seismographs. In Southern California, where this interest in amateur seismology is quite high, an amateur seismological league has been formed for the exchange of information and records. Plans are under way to form a similar league in Nevada, and it is hoped that ultimately a similar league will eb formed here in the Northwest.

Ecological Aspects of Soil Erosion in the Pacific Northwest as Determined by the Reconnaissance Erosion Survey

A. L. HAFENRICHTER* and W. A. ROCKIE**

The study of soil erosion has received a great deal of attention during the past decade. The relationship of soil erosion to problems of crop and livestock production, flood control, navigation, power development and drought periods has been pointed out repeatedly. Research work has been inaugurated to study the exact degree of erosion under a variety of climatic and edaphic conditions and to ascertain the effectiveness of control measures.

Two kinds of erosion are generally recognized; namely, normal (geologic norm) and accelerated. The present paper will deal largely with accelerated erosion. This type has been described by Lowdermilk[2]*** as "artificially augmented processes of wind and water erosion under potentials caused by the removal of controls exercised by a mantle of vegetation." Another definition given by Frissell[5] et al. is "erosion wihch has been increased above that which existed under natural environment, either as a result of the destruction of vegetative cover or by some activity of man."

Several factors influence the degree to which erosion is accelerated on a given area. Among the more important are topography, climate, soil type, vegetative cover and system of land management. It is apparent that only the last two are directly within the control of man. Accelerated erosion, whether the result of water or wind action, occurs but rarely when the soil is clothed with an adequate cover of vegetation. On uncropped land, this cover may be a climax plant association or one of the subclimax associations. In any case, the nearer the succession is to the climax plant association, the better the control. On land that is cleared or broken and used for agricultural purposes, an adequate vegetative cover is difficult of definition. It might be described in general terms as one which effectively protects the soil against wind and water erosion. Adequate protection of the soil on cropped land may be accomplished in several ways and it is obvious that the methods employed would vary with such factors as climate, soil type, economic conditions, types of farming, etc. The essential point is that the process of cropping the land has removed the permanent vegetative cover and has substituted temporary vegetation interspersed with clean cultivation. Under such conditions, stringent methods of soil conservation must be used to obviate accelerated erosion.

Both wind and water erosion are common in the Northwest. It is difficult to say which of these is the more destructive. On much of the area affected by wind erosion, water erosion also occurs. Both of these types of erosion have many indirect influences. One of the more important indirect influences is that associated with water erosion. It is axiomatic that water erosion is always accompanied by loss of a considerable portion of precipitation as run-off. This point cannot be regarded lightly, since it is generally conceded that moisture is the limiting factor in production on a very important part of the agricultural and grazing land and, to some extent, the forest land of the Pacific Northwest. In a region where moisture is the limiting factor in production, any loss of precipitation as run-off is critical. It is a common observation and has support from experimental data that run-off and attending

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***Reference is made by number to literature cited, page 10.

soil losses can be controlled, and in many cases eliminated.

A large number of workers are recognizing that the problems of land use cannot be solved without due regard to erosion and erosion control. Bennett[2] has pointed out the rapidity with which the land resources of the Nation are being depleted by erosion processes. This depletion has far-reaching effects and is probably one of the major influences affecting the complex problems of agriculture in the United States today. Land that has been improperly used or incorrectly managed has suffered severely from soil losses through the agencies of wind and water erosion. If the potentialities of erosion had been known, many catastrophies might have been averted. The application of this statement to land use in the future is obvious.

Although general facts about erosion in the Northwest were known, no data were available to show the exact conditions that obtained on the different types of land in this section. In order to obtain such data an erosion survey was made by the U. S. Soil Erosion Service* in 1934.

*On April 27, 1935, this name was changed to the Soil Conservation Service.

Methods

The erosion survey was made in the field after the method of a general reconnaissance by a crew of trained workers. Agricultural and grazing lands were inspected closely. The survey of forest lands was more indirect. The information with respect to forest lands was obtained from cover maps and other data made available through the courtesy of the U. S. Forest Service. Examinations were made of typical areas under known conditions and these were used as a basis for mapping erosion on forest lands in general.

Extensive notes were taken in the field. These were based on a specific set of criteria designed for use in appraising erosion conditions. Factors influencing erosion were recorded and suggested control measures were ascertained and included in the notes. For the purpose of expressing the results of these observations a system of legends was worked out. These legends were placed on the field notes in the manner of a formula. On this formula a unit area of land was classified with respect to (1) soil type by textural description, (2) present land use, (3) slope gradient, (4) types and degrees of erosion, and (5) control measures that would probably be feasible.

The county was used as a unit for field work. It is realized that this unit is artificial, but it was chosen because other types of data are usually compiled on this basis. Maps are also available on the county basis. The survey data will probably be re-worked with the watershed as a basis rather than the more artificial county unit.

A map was made for each county, the areas delimited and the formula applied. To supplement this the field notes for each area were written up. The data from the county were transferred to state maps drawn to the scale of eight miles to the inch. In making such a transfer, it is obvious that considerable generalization is necessary. For the purpose of generalization sixteen erosion classes were designated. Each of these classes was described to show the average conditions that exist, without reference to localized conditions or degree of variability. These sixteen classes will probably suffice for general purposes, but they are undoubtedly insufficient for detailed work. Four degrees of water erosion and three degrees of wind erosion were chosen and used in designating the erosion classes. The descriptive terms *slight, moderate, serious* and *severe* were applied to the degrees of water erosion. The terms *slight, severe* and *very severe* were used for degree of wind erosion. The final erosion classes adopted for classifying land areas, combined degree of erosion with land use. Eight

erosion classes apply to agricultural land, four to grazing land, three to forest land and one to wasteland.

The data collected by a survey of this kind might be presented in several ways. The type of presentation would depend largely on viewpoint. However, it is felt that the segregation of erosion into groups such as has been done in making the erosion classes will make the data available in the most usable form irrespective of specific viewpoint.

Results

The data from the reconnaissance erosion survey were tabulated to show the acreage in each erosion class. Data for agricultural land, open range land and forest land were compiled separately. Computations were made to express the per cent of the total agricultural, range and forest land that was found in each erosion class. A further segregation of the data was made to separate results obtained in western Oregon and Washington from those obtained in Idaho, eastern Oregon and eastern Washington. The land area in Idaho, eastern Oregon and designated as the Intermountain Zone of the Pacific Northwest. That west of the Cascade Divide will be referred to as the North Pacific Zone. The data thus obtained are, for convenience, shown graphically rather than in tabular form.

Intermountain Zone

Figure 1 shows the distribution of erosion by classes on agricultural land in the Intermountain Zone of the Pacific Northwest. The figures show the per cent of the total agricultural land that falls into each of the eight erosion classes. Approximately 30 per cent of the agricultural land in this zone is irrigated. The remainder is non-irrigated. The non-irrigated land is divided into seven erosion classes, four of which apply to water erosion only; three to a combination of wind and water erosion. In the latter case, wind erosion is regarded as the more important.

Approximately one-half of the non-irrigated agricultural land in the Intermountain Zone is affected by water erosion only. An inspection of the figure shows that most of the agricultural land affected by this phase of erosion is in

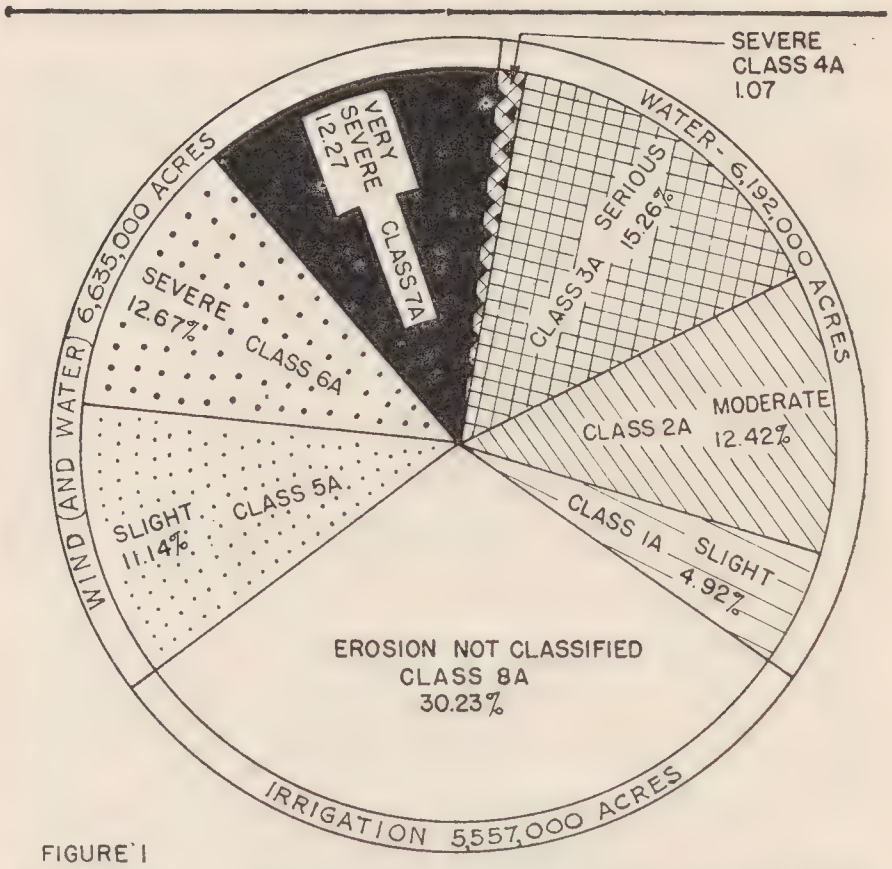


FIGURE 1. Distribution of kinds and degrees of accelerated erosion on 18,384,000 acres of agricultural land in the Intermountain Zone of the Pacific Northwest. Figures indicate percent of total land in each class.

classes 2A and 3A. This is very significant insofar as the Northwest is concerned. It means that nearly 28 per cent of all agricultural land in this zone is either "moderately" or "seriously" eroded. Broadly speaking, this means that 50 per cent or over of the surface soil has already been removed from the land in these two classes. This may be stated in still another way; namely, that on a little over five million acres of agricultural land in the Intermountain Zone less than half of the surface soil remains. This surface soil has not been removed in a uniform layer due to the unique topographical conditions that obtain. It has been entirely removed along with some subsoil in parts of fields, partially removed in others and some has been re-deposited on the lowlands. As a result, subsoil farming is practiced on some of the land while rich fertile lands that represent the potential

crop producing areas of the future are being damaged by depositions of silt and clay. It must be remembered that most of the agricultural land in the Intermountain Zone has probaly not produced more than thirty crops. It is still relatively young and already seriously eroded.

Figure 1 also reveals that a little less than 5 per cent of the agricultural land in the Intermountain Zone is adequately protected against water erosion. Further, only a trifle over 1 per cent has been irretrievably ruined by this process. Combining these facts with those just cited, it is evident that very little agricultural land has been completely ruined, very little is adequately protected and from the majority of the land serious soil losses have occurred. When the distribution of water erosion classes on agricultural land shown in Figure 1 is compared with the facts that are known for erosion on agricultural lands in other parts of the country, one thing is notable; namely, that stringent erosion control measures must immediately be instituted and maintained to save this valuable land. Unless this is given attention in the immediate future, the amount of land that will be irretrievably ruined is destined to increase rapidly.

Figure 1 indicates three classes of wind erosion on agricultural land. Approximately 36 per cent of the agricultural land in the Intermountain Zone of the Pacific Northwest falls into these three classes. The data show that slightly more than 11 per cent of the total agricultural land is in the class designated as "slight wind erosion" (Class 5A). Briefly stated, this designation means that this land has drifted but little and can still be protected against serious damage from wind erosion. If this is done it can be farmed for some time to come. A little over two million acres of land are in this class. In contra-distinction to this, slightly more than four and one-half million acres or about 25 per cent of the total agricultural land has been damaged by wind (and water) erosion to the point where much of it has already been abandoned, a large area is in the process of abandonment and all of it probably will be abandoned in the not distant future (Classes 6A and 7A). Although it is probable that much of this area should never have been devoted to cultivated crops, it is now a distinct liability to the Northwest. A major portion of it must be dedicated to a new use.

It is a known fact to those familiar with erosion conditions that wind erosion is not only serious in itself, but is a menace to the land lying to the leeward. The area of agricultural land affected by wind erosion has been increasing gradually and surely, but the extension has been to the leeward. It is consequently obvious that if valuable lands adjacent to wind erosion areas are to be protected, soil drifting must be checked, and soon.

A little over five and one-half million acres, or approximately 30 per cent of the agricultural land in the Intermountain Zone of the Pacific Northwest is irrigated (Class 8A). The value of this land is common knowledge. Erosion has not been classified on these lands, chiefly because sufficient research work is not as yet available. It is known, however, that these lands are subject to both water and wind erosion. The degree of erosion that has taken place depends upon topography, the way in which irrigation water is handled, the availability of water and the type of cover that is maintained. More detailed work is necessary, but it is quite clear after cursory examination, that erosion on these lands calls for more attention than has been accorded it in the past. It is also obvious that some of these lands should not have been utilized in this way, chiefly because of erosion potentials. This should be an ominous warning.

Irrigated lands are affected indirectly by erosion. Reference is made to the silt-

ing in of irrigation reservoirs by accelerated soil erosion on the watersheds that feed them. Further study is needed before specific statements can be made but data are available to indicate that in some instances silting in has been rapid and is materially reducing the storage capacity of such reservoirs. This problem must be recognized, even though the effect is indirect.

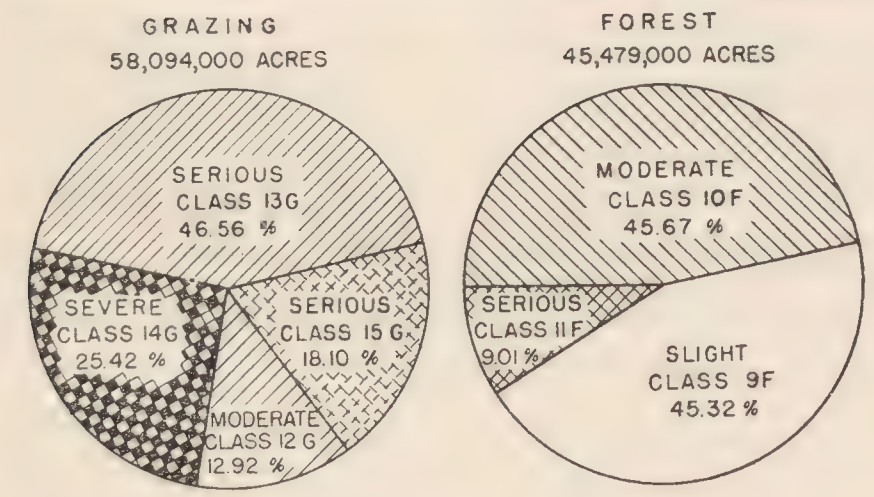


FIGURE 2

FIGURE 2. Distribution of degrees of accelerated water erosion on 58,094,000 acres of open range grazing land and 45,479,000 acres of forest land in the Intermountain Zone of the Pacific Northwest. Figures indicate percent of grazing or forest land in each class.

Figure 2 shows the distribution of erosion on grazing land and forest lands in the Intermountain Zone of the Pacific Northwest. The grazing lands here shown refer to the "open range" type of grazing land. It will be seen that the distribution of erosion classes on open range is somewhat the same as that for agricultural lands; namely, a relatively small acreage has been "severely" eroded (Class 14G). a still smaller percentage has been "moderately" eroded (Class 12G), and by far the greatest amount has been "seriously" eroded (Class 13G). The class 15G refers to grazing land in coulees, river breaks, scablands, lava flows, etc., and will be discussed separately. With this distribution of erosion classes on open range, essentially the same conclusions may be drawn as were those for agricultural land. A broad interpretation is that a very large part of these lands has been eroded to the point where soil losses are large and measures must be taken immediately to restore a protective cover lest the ranges rapidly be ruined to the point where they will not support an adequate forage cover. ...This point merits more attention than it has received but examples of attempted restoration of the native grass cover on severely eroded range lands in the Northwest clearly show that such lands will support but a small fraction of the vegetation they were known to have in the virgin condition. Also, a relatively small part of the open range land is now adequately protected against serious soil losses by the forces of water and wind erosion.

Erosion on grazing land in coulees, river breaks, scablands, etc., is exceedingly variable and difficult to classify in large units. The method of grazing them is variable. In aggregate these lands have a considerable acreage and are of no little importance. As an average it is safe to say that the erosion that has occurred is "serious" and the present condition is not unlike that of Class 13G.

There are nearly fifty-eight million ninety-four thousand acres of open range grazing land in the Intermountain Zone of the Pacific Northwest. Approximately seven and one-half million acres are but moderately eroded. Thirty-six million that are seriously eroded include about eleven million acres that are coulees, river breaks, scablands, etc. Erosion on this thirty-six million acres is not entirely uniform, but in aggregate at least fifty per cent of the surface soil has been removed. More than this has been lost from the range land in the "severely" eroded class.

The data with respect to forest land are also found in Figure 2. These figures are subject to some revision. In general, they show that approximately 45 per cent of the forest lands are protected with a vegetative cover that is regarded as adequate to control erosion and retard run-

off. In representing the forest cover, both the tree cover and the undergrowth are taken into consideration. In some cases, especially in open park types, the latter is probably the more important controlling influence. Approximately 9 per cent of the forest lands have a cover that is totally inadequate to control erosion. This figure may be too low. The remaining 46 per cent exerts some control but the cover is not sufficient to allay accelerated erosion.

The influence of forest cover on run-off and erosion in the Intermountain Zone of the Pacific Northwest has been summarized by Munns et al.[3] In this discussion may be found an analysis of the effects of forest cover on these processes and suggested feasible control measures. The agencies causing forest cover depletion are also discussed. The forest cover in this section exerts its principal influence with respect to the Columbia Basin Drainage. In this drainage are now located some of the most important reservoirs of the Northwest. The watersheds above these reservoirs must be regarded in the light of their control over "silting in."

An important fact resulting from the survey was that apparently only a relatively small portion of the watershed need be denuded of vegetation to exert an important influence on the amount of total run-off and erosion. Similarly, for a given watershed the removal of the vegetative cover beyond a certain critical point appears to have a disproportional influence on run-off and erosion. The bearing between these points and flood damage is obvious. These points are deserving of careful study and analysis, not only because of their importance, but in the light of affording more careful protection to existing cover.

North Pacific Zone

The second problem area in the Northwest is the North Pacific Zone, which contains the parts of Oregon and Washington lying west of the Cascade Mountain Divide. The principal types of land in this zone are forests, agricultural land and wasteland. A relatively small per cent can be classed as being used chiefly for grazing purposes. Climatic, topographic and soil conditions are different from those in the Intermountain Zone. These factors are interrelated with the type of vegetative cover and the rate of erosion. In western Oregon about 17 per cent of the land area is devoted to agriculture while in western Washington less than 9 per cent is used for this purpose. Less than 5 per cent of the land in western Washington and less than 1 per cent in western Oregon is classed as wasteland having no vegetative cover.

Erosion damage on agricultural land in the North Pacific Zone has not progressed to the point reached in the Intermountain Zone. This difference is due to many causes among which the system of land management may be regarded as primary. Other factors are topography, character of rainfall, and edaphic conditions. However, many of these lands have a high valuation and although erosion has not progressed rapidly, moderate soil losses cannot be regarded lightly. Generally speaking, the greatest damage to agricultural land in this zone is caused by floods.

The degree of flood damage is large but it is more acute in western Washington than in western Oregon. The reasons for this are several but difference in topography is apparently the chief one. The erosion data for this zone must, because of the reasons given, be studied with respect to watersheds. Detailed analysis will not be given but certain broad concepts deserve discussion. The analysis of watershed data makes it appear that both normal and accelerated erosion probably affect flood conditions. The exact degree of influence exerted by each has not been determined. However, it appears that some of the most serious recurrent floods,

especially in western Washington, occur on watersheds where the vegetative cover has been removed and regeneration is not taking place or is occurring very slowly. Here again evidence was obtained to show that the vegetative cover need be removed from only a relatively small portion of a watershed to materially accentuate accelerated run-off and erosion.

Although the evidences have not been fully obtained or analyzed, it appears that watersheds having a high slope gradient, receiving a high precipitation and containing a considerable amount of unvegetated wasteland are subject to certain flood conditions. However, if by fire or other influences, some of the cover is destroyed, the effect on run-off is pronounced.

DISCUSSION

The land area of the Northwestern states has been divided into two zones: the Intermountain Zone and the North Pacific Zone. In the Intermountain Zone there are slightly more than eighteen million acres of crop land, a little over fifty-eight million acres of open range land and approximately forty-five million acres of forest land. In the North Pacific Zone, less than five million acres are crop land, thirty and one-half million acres are forested and eight hundred fifty thousand acres are classed as wasteland.

By far the larger per cent of the agricultural land in the Intermountain Zone presents a serious erosion problem. Four and one-half million acres have been badly damaged by wind erosion. Approximately five million acres are already either moderately or seriously eroded by water. Irrigated land has not been classified. The most significant fact disclosed by the survey data is that erosion can still be checked on the most valuable agricultural land if proper control measures are instituted immediately.

Erosion on agricultural land in the Intermountain Zone is due to several factors. The more important are topography, climate, soil, vegetative cover and system of land management.

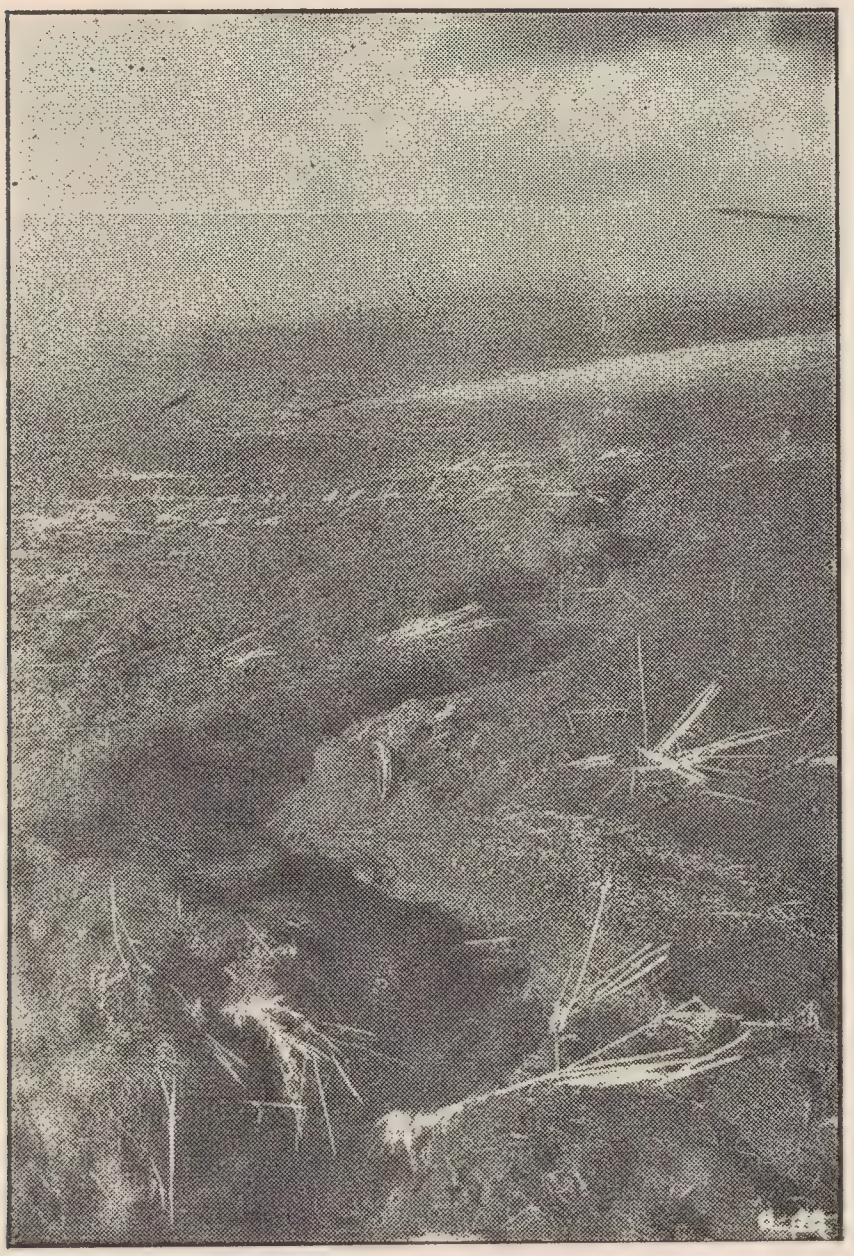
The topography of agricultural land in this zone of the Northwest can best be discussed with respect to the type of erosion. Land that is irrigated is relatively level with slope gradients varying up to 10 per cent. Other than irrigated lands, slope gradients seldom average less than 5 per cent and a large acreage of the most vauable land will average 20 to 30 per cent. In this large acreage is the Palouse wheat belt. The unique topography of this formation is well known. The steeper land is, for the most part, affected by water erosion only. The rolling and low hilly lands (10 to 25 per cent slope gradient) are affected by both wind and water erosion. It is therefore apparent that relatively steep land is being cultivated in the Intermountain Zone.

The climate of the Intermountain Zone is very variable. The most common feature is that the precipitation occurs in the late fall, winter and spring months. The summer months are rainless except for occasional torrential rains. Chinook winds are common and spring run-off may or may not occur when the ground is frozen. On most of the farm land where wind erosion is common the average annual precipitation is less than 15 inches. The most serious water erosion occurs where the average precipitation is above 15 inches. The absence of much summer rainfall is probably the reason why relatively steep lands are cultivated. However, this fact has brought about methods of land management that are especially conducive to accelerated erosion.

Soil surveys are available for only a few areas in this part of the Northwest. In the absence of this much-needed information only broad generalizations are possible. The largest areas of serious wind erosion occur on fine sandy loam types. There are areas where wind erosion occurs on loam types and on sandy types. The areas showing water erosion only usually

have silt loam or loam soils but sandy loams are also eroded by this agency. The inter-relation of many other factors is recognized. The soils of the irrigated areas are largely sands and fine sandy loam and are easily eroded by water and wind.

The factors of topography, climate and soil must be recognized but, as previously



Sheet erosion on Palouse silt loam in Latah County, Idaho. Continuation of sheet erosion will undoubtedly result in gully formation. Run-off from the hilltop that had been washed down to the clay subsoil accumulated rapidly to cause the severe erosion noted in the immediate foreground.

shown, the type of plant cover that is maintained and the system of land management are the two factors that are within the control of man.

In the Intermountain Zone a moderately small amount of agricultural land is devoted to perennial crops that protect the land, especially during critical periods. By far the larger per cent of the land is farmed by the summer-fallow method or is devoted to the raising of cultivated crops. On the non-irrigated lands approximately 40 per cent of the land lies in the "fallow" condition, hence is totally unprotected during the rainy periods, during the period of spring run-off or when wind erosion is likely to occur. It has been shown by Rockie[4] that the summer-fallow system of farming is the direct cause of accelerated erosion on such lands. Under this system land is eroding rapidly. This in itself is serious but the indirect effects are equally serious. For example, in the so-called Palouse region of the Pacific Northwest as much as 35 per cent of the water that falls as rain has been known to be lost as run-off. This is occurring in a region where moisture is known to be the limiting factor in crop production. The indirect effects of this run-off on soil processes, underground water supply and flood hazards can readily be imagined. Wind erosion is more serious on agricultural land when it is in the fallow condition. Not only is the land itself damaged, but adjacent areas are being affected. Changes in system of management to adequately protect the agricultural land in this part of the Northwest will require the dedication of some areas to a new use, a change in the type of farming in other areas and a modified system of land management on the remainder. These changes must come soon if the land is still to be saved. If they are not instituted and maintained in the near future, the land will have to be salvaged.

Essentially the same conditions exist in the open range land in this zone that were found on agricultural land. The larger part of the fifty-eight million acres of this land is already seriously eroded. The actual and potential erosion condition can be appraised from the distribution of erosion classes. The facts show that much of this acreage can be protected if strin-

Wind erosion in Adams County, Washington. Soil was removed down to plow depth. Note that each thistle held sand on its leeward side.

gent erosion control measures are immediately instituted.

Erosion on grazing land is associated with the removal of the cover by over-grazing with stock and by rodents. It is significant that this cover need not be removed entirely before serious soil losses occur. When it is destroyed to a certain critical point, further over-grazing rapidly accelerates erosion. Although much of the open range land is subject to some wind erosion, by far the greatest damage has been caused by water. This means that much of the precipitation is being lost as run-off. This in itself is serious and is without doubt one of the probable causes for the so-called "drought years." One man who has been associated with the livestock industry on this land for many years put it this way: "We have had dry years before but none have had the effect of this last one."

It is apparent that the protection of open range lands depends on the restoration of the grass cover. If this were done it follows that the carrying capacity of the range would also be increased. Restoration of the cover on these lands is still possible by the relatively inexpensive expedient of carefully managed grazing. The method of management will necessarily be dependent on local conditions. Some ranges are grazed during the winter while many are grazed throughout the year. In some instances management may even mean some form of restriction but this may be necessary to preserve the land for grazing use. Irrespective of the form of management, it must be done in the near future or it will be virtually impossible to establish a grass cover because of the rate at which the surface soil is being removed. The present subdominant cover of sage and ruderal vegetation is inadequate to control erosion and run-off or prevent drifting. Reseeding of severely eroded ranges is frequently suggested but this method is expensive and has not yet been proved practical. Without topsoil it is a very questionable practice.

Range lands are not usually thought of in relation to reservoirs and waterways but there are instances where this relationship may require serious attention.

The forest lands of the Intermountain Zone have been subjected to less erosion than agricultural and grazing lands. There are approximately forty-four million acres of such land. A large proportion of these forests are extensively used for grazing. Because of this, the undercover assumes a considerable importance. Erosion and run-off on forest lands is also associated with the type and amount of cover. Twenty and one-half million acres have a vegetative cover adequate to control erosion processes. The cover on the remainder has been removed to a point where it does not exert adequate control.

Forest lands must be regarded with respect to their value for watershed protection. Consequently the location of poor cover is even more important than its extent. It is significant that a relatively large acreage cannot adequately control erosion and that some of the worst erosion is occurring where floods are doing considerable damage. An important point in the relation between run-off and forest cover is that a relatively small area of a watershed need be denuded to cause a marked difference in the acceleration of run-off and erosion.

The restoration of forest cover may be brought about by natural succession but in many instances factors are at play to retard or prevent revegetation. Where artificial restoration is necessary it must be regarded with respect to its practicability. Watershed protection probably justifies this procedure. For the most part, it is generally felt that the provision for increasing forest protection measures would be better economy.

The North Pacific Zone has an erosion problem distinct in character from that of the Intermountain Zone. There are major differences in causal factors, rate of erosion and necessary control measures. From the ecological viewpoint the basic facts are much the same for the accelerated phase of erosion in the two zones. The important result of the findings of the erosion survey are that the controlling influence of the forest cover on important watersheds has not been given full attention. Severe erosion in the North Pacific Zone is chiefly the result of floods. In this zone there is at hand a potentially good protective cover, especially in the climax association. Factors operating in this zone are conducive to rapid revegetation but frequently processes may prevent this. It appears that where the forest cover has major watershed-protection value, several things deserve careful consideration: (1) An accurate determination should be made of the degree to which erosion has been accelerated on important watersheds. (2) The relation between the vegetative cover and floods deserves more attention than it apparently has been given. (3) Where the balance between cover and accelerated run-off is especially critical, this relationship is important and probably has considerable bearing on the economy of controlling floods. (4) It would also be important to know the point at which succession after partial or complete denudation would exert a given degree of control over run-off and erosion. (5) Every effort should be made to give existing cover the maximum amount of protection.

SUMMARY

1. Data are presented to show the types and degrees of erosion on agricultural, open range and forest lands in the Pacific Northwest. These data were obtained by a reconnaissance erosion survey.

2. Accelerated water erosion occurs on all sloping land in the Pacific Northwest when the soil is not protected by an adequate vegetative cover. Accelerated wind erosion is also prevalent on land not properly protected but is not influenced

The Effect of Poisons on the Neuromteer System of Ichthyophthirius

By RONALD F. MacLENNAN
State College of Washington

Definite coordinated movements and specific behavior patterns have been recognized in the protozoa, particularly the ciliates, since the work of Jennings (1906). The morphological basis of these behavior patterns was unknown until Sharp (1914) described a centered system of fibrils linking all the cilia into a single morphological unit, the nepromotor system. Taylor (1920) and various later

---

by slope gradients. The rate of acceleration of both kinds of erosion is rapid on most lands in the Northwest.

3. The problems of accelerated erosion in the Intermountain Zone of the Pacific Northwest are different from those in the North Pacific Zone. Control of erosion is also different in these two divisions. The damage caused by erosion in the Intermountain Zone is mostly direct, while that in the North Pacific Zone is also indirect. In the latter floods are especially destructive.

4. The distribution of erosion by classes on agricultural and grazing land in the Intermountain Zone shows that the larger part of each type is already seriously eroded, only a small proportion is adequately protected and little is entirely ruined, and that much of the land can be retained for its present use if erosion control measures are immediately instituted. Some general control measures are suggested. On forest lands, serious erosion is less extensive but has occurred.

5. It is shown that there is a critical point after which the removal of slightly more cover or continued improper land management greatly accelerates erosion processes. The indirect effect of erosion after this point is reached is often as important as actual soil losses. Reference is made to run-off, ground water supplies, floods, soil accumulations and natural revegetation.

6. Restoration of vegetation by natural succession under proper protection is still possible and economical on most of the range and forest lands. If erosion continues unchecked this cannot be done. There is an apparent balance between the degree of cover depletion, erosion and revegetation. On agricultural land important changes in use and management must be made to protect soil during critical erosion periods.

7. It is probable that geologic norms of erosion are a factor in flood conditions in the North Pacific Zone. Accelerated erosion also occurs. The exact extent of each of these kinds of erosion is not known but more attention must be given to the control of the accelerated phase.

The authors gratefully acknowledge the cooperation of the U. S. Forest Service, the U. S. Indian Service and the Bureau of Chemistry and Soils in making this survey.

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Editorial Postscripts

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T. LARGE.

ingested with the food vacuoles. This heightens the effect of the failure of diastole in the contractile vacuoles.

Definite changes in the neuromotor system do occur after a considerable period. First, the oral cilia beat more slowly than the body cilia and finally cease altogether. Then the body cilia lose their coordinated beat and finally become quiescent. When the fibrils are stained according to the silver methods of Klein, it is seen that they have become thin and inconspicuous. This change is difficult to use as a criterion of change because of the amount of variation inherent in methods using silver impregnation. To overcome this difficulty young ciliospores were taken during the period when redifferentiation of the mouth occurs in the hope that young fibrils in the process of formation would be more susceptible and show definite morphological evidence of disturbance. Positive results were attained with chloretone in 1/4-1/8 saturated solution.

The number of oral fibrils were counted in two different series both of which were fixed and impregnated 24 hours after excystment. One series was the normal control, the other had been immersed in 1/8 saturated chloretone for 24-36 hours. The normal controls possessed 5-9 oral fibrils, and 65% had 6. The poisoned individuals had 0-3, 60% had only one. In the same two series the number of longitudinal somatic fibrils on one side were counted as a measure of the changes in the somatic cilia. The number of rows in the normal controls was 19-27, in the poisoned individuals 21-26. Fifty per cent of the controls had 20-22 rows, 60% of the poisoned ones had 21-22 rows. The total number of somatic rows in each ciliate is very nearly twice the numbers given above. The dry silver-line method stains only the outer half-surface, the half-surface attached to the slide is unstained.

The differentiation of the mouth is inhibited by chloretone, the somatic fibrils, however, were undisturbed. The somatic fibrils undergo most rapid multiplication some time before excystment, while the oral fibrils are differentiated to a large extent after excystment. The conditions of the experiment were such that the inhibiting environment was applied to fully differentiated somatic fibrils and to oral fibrils right in the process of differentiation. Thus a dilution which is insufficient to destroy structures already laid down does inhibit their differentiation. This result can be compared to the critical periods found by Stockard in fish embryos and also to the greater susceptibility in regions of greatest activity, found by Child and his co-workers.

CONCLUSION

Inhibition of differentiation of the neuromotor system can be induced by the use of chloretone. Once the fibrils are laid down they are relatively resistant and only slight changes can be produced before the death of the individual.

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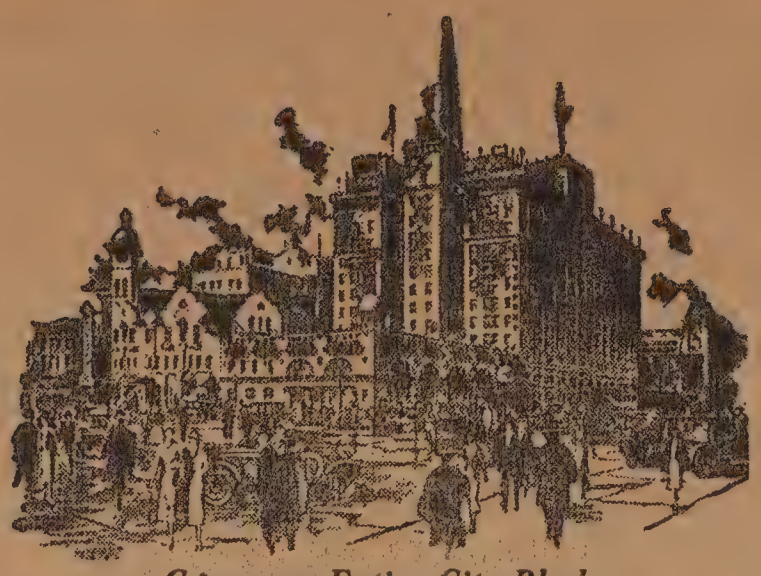

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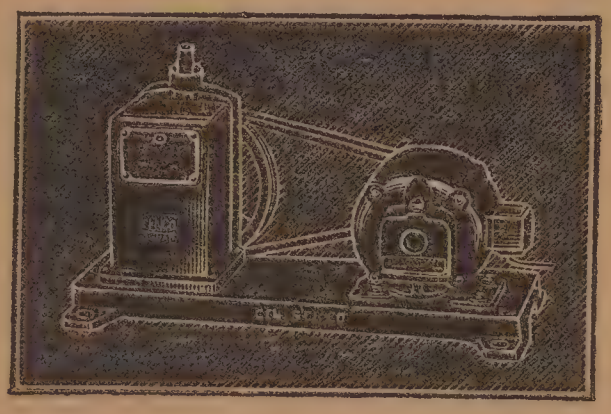

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The new editor of **Northwest Science** urgently requests that members of the Northwest Scientific Association send him news items concerning research products and other activities undertaken by individuals and institutions in the Northwest. It is planned to devote a page or more in each issue to such current information if it can be secured. The news notes should be sent to the editor, O. W. Freeman, Cheney, Washington.

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Annual Meeting of the Northwest Scientific Association

By W. B. MERRIAM, Secretary

The fourteenth annual meeting of the Northwest Scientific Association, held on December 28 and 29 at the Davenport Hotel, Spokane, Washington, had an official registration of 148, although visitors and guests swelled the attendance to more than 200 at the section meetings.

The speaker at the opening general session was Dr. E. C. Johnson, dean of the College of Agriculture, State College of Washington, Pullman, who related some of his summer's observations on the collective farms of the U. S. S. R. at the annual dinner. Dr. H. K. Benson, head of the department of chemistry and chemical engineering, University of Washington, Seattle, gave the principal address, speaking on "The Application of Chemistry to Industry." At the joint luncheon with the Associated Engineers of Spokane, on the second day, Dr. Benson also spoke, taking as his subject "A Chemurgic Program for the Northwest."

The annual Sigma Xi breakfast was followed by an illustrated lecture on the origin of Crater Lake, entitled "Mt. Mazama—Explosion vs. Collapse," presented by Dr. Warren D. Smith, chairman of the geology-geography department at the University of Oregon, Eugene.

Aside from the general sessions, special section meetings were held for the following groups: (a) Bacteriology and Public Health; (b) Botany-Zoology; (c) Chemistry-Physics-Mathematics; (d) Education-Psychology; (e) Engineering; (f) Forestry; (g) Geology-Geography; (h) Social Science, and (i) Soil Conservation. A total of 90 papers were presented.

Officers elected for 1938 include: Dr. J. H. Ramskill, Montana State University, Missoula (forestry), **president**; Dr. E. F. Gaines, State College of Washington, Pullman (agronomy), **vice president**; W. B. Merriam, Eastern Washington College of Education, Cheney (geography), **secretary-treasurer**, with Dr. C. C. Todd, Pullman, retiring president, and Dr. E. C. Jahn, University of Idaho, Moscow, **councilors**.

Trustees elected were: E. M. Keyser, Spokane, and Dr. William H. Cone, Moscow, Idaho, for the three-year term, and Thomas Large, Spokane; C. C. Johnson, Pullman, and Gerhard Kempf, Priest River, Idaho, for the one-year term. Dr. O. W. Freeman, Cheney, was elected editor of **Northwest Science**, the official publication of the association.

It is expected that the annual meeting for 1938 will be at the Davenport Hotel, Spokane, on December 27 and 28.

The following section officers were elected:

Bacteriology-Public Health—Chairman, Dr. Richard A. Koch, Health Officer, Whitman County, Colfax, Washington; Secretary, Mrs. Jacqueline Bahrenburg, St. Luke's Hospital, Spokane, Washington.

Botany-Zoology—Chairman, R. N. MacLennan, Washington State College, Pullman, Washington; Secretary, C. S. Sharsmith, Washington State College, Pullman, Washington.

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Chemistry-Physics-Mathematics—Chairman, Dr. L. C. Cady, Dep't of Chemistry, University of Idaho, Moscow, Idaho; Secretary, Dr. R. W. Gelbach, Chemistry Dep't, State College of Washington, Pullman, Washington.

Education-Psychology—Chairman, Dr. J. W. Barton, University of Idaho, Moscow, Idaho; Secretary, Dr. C. I. Erickson, Washington State College, Pullman, Washington.

Engineering—Chairman, W. L. Maloney, Symons Building, Spokane, Washington; Secretary, A. C. Butler, City Hall, Spokane, Washington.

Forestry—Chairman, Thomas Lommasson, U. S. Forest Service, Missoula, Montana; Secretary, R. M. DeNio, U. S. Forest Service, Missoula, Montana.

Geology-Geography—Chairman, W. A. Glenn Bennett, State College of Washington, Pullman, Washington; Secretary, Thomas H. Hite, University of Idaho, Moscow, Idaho; Director, Round Table, Dr. Ralph L. Lupher, Washington State College, Pullman, Washington.

Social Science—Chairman, Albert J. Partoll, University of Montana, Missoula, Montana; Vice Chairman, W. B. Merriam, Eastern Washington College of Education, Cheney, Washington; Secretary, Miss Mary Sidney Mitchell, North Central High School, Spokane, Washington.

Soil Conservation—Chairman, Paul McGrew, Soil Conservation Service, Spokane, Washington; Secretary, Mark R. Kulp, Idaho Agricultural Experiment Station, Moscow, Idaho.

In Memoriam

Dr. W. A. Buice, a member of the Northwest Scientific Association since 1932, died at Santa Monica, California, early in February, at the age of 45 years. Dr. Buice was both a bacteriologist and physician. During 1937 he intensively studied the problem of the pollution of the Spokane River by sewage and industrial wastes from Spokane and vicinity, for the city of Spokane, and barely finished his report before his death. Dr. Buice was interested in psychology as well as medicine, and for several years served on the staff of the Eastern Washington Hospital at Medical Lake, where part of his work dealt with mental health.

Dr. Buice was a native of Oklahoma, and in his death science in the Northwest has lost a sincere, capable investigator.

* * *

Dr. Charles M. Doland joined the Northwest Scientific Association in 1927 and continued an active member until his death, March 13, 1937. Dr. Doland was a prominent and successful member of the medical fraternity in Spokane for many years, belonging to the Spokane County Medical Association, the Washington Medical Association, and the American Medical Association. For many years Dr. Doland served as physician for the Northern Pacific and Union Pacific railways.

The Application of Chemistry to Industry

By H. K. BENSON
University of Washington

In addressing an audience of scientific persons, it is not my intention to boast of the accomplishments of science in recent years. It is remarkable to what extent the general public has become interested in the scientific phases of our modern life. In the current number of the magazine Fortune, many pages are given to an excellent portrayal of the part that chemistry has played in industry and its prophecy of the part that it will play in future industry is even more remarkable. Quite recently large audiences greeted the polished secretary of the American Institute, Dr. Gerald Wendt, in his spectacular lecture, Science on Parade, delivered before Western audiences. Paul Muni of Hollywood has brought the life of Pasteur into a living knowledge of millions of people. It is my intention at this time to emphasize the mechanism or the ways and means by which chamistry is advancing our industrial well-being, and thus contributing to the comforts and the happiness of our people. It is difficult for those of us engaged in scientific work to evaluate the significance of many of the things we teach. We are like the traveller in the forest who is unaware of the glorious heights nearby from which a view of the world may be had. In order that we may gain perspective and thereby a better appreciation of the little menial tasks we do each day in the field of science, I would like to consider the background of chemistry rather than to guess its future: to analyze the forces that played back and forth and have brought chemistry to its present stage of activity in the world's affairs; and finally, to inquire into the effect it may have upon the social and economic conditions of the day.

As the writer in Fortune says: the activities of chemical industry can best be expressed by saying that it is engaged in making something into something else, not by altering shapes and sizes visible to the eye but by working with the unseen and unseeable materials of the chemist, viz: atoms and molecules. Using heat and pressure mainly it busies itself with making things that are new, things that are cheaper, things to make other things, things that the eye of the ultimate user seldom if ever falls upon.

Yet from undertakings so diversified chemical industry has had its origin. It goes back to the year 1791 and to a Frenchman named LeBlanc—Nicholas LeBlanc. He was not a great chemist; not a great research man or teacher, but rather a simple minded man who wanted to make some money. The French glass factories famed for their beautiful products the world over, were unable to get sea weed ashes from the Coasts of Spain on account of a military blockade by the English armies. The French Academy offered a prize of 12,000 francs for a process whereby the soda extracted from sea weed ashes could be made from salt, thus making the glass factories of France independent of Spain and the hindrance of British armies. Just how the French Academy hit upon salt as something to be used for making soda is remarkable inasmuch as at that time the element sodium was yet to be discovered. Perhaps it was intuition; perhaps it was due to the sea water of the French Coast; perhaps it was a stab in the dark; but anyhow, it was right because Nicholas LeBlanc treated salt with sulfuric acid, roasted the salt cake with charcoal and chalk and extracted the

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"black ash" instead of the sea weed ash with water and obtained beautiful crystals of soda which he sold to the glass factories. Once LeBlanc had done it, it was as simple as that.

I am interested at this point in knowing what it was that enabled LeBlanc to do this. His contemporaries were much more brilliant than he. Lavoisier, the father of modern chemistry, was famous enough to be guillotined in 1794, even before the revolutionists had confiscated LeBlanc's factories and driven him to his death. Henry Cavendish and the great Joseph Priestley were his contemporaries—great figures in the unfolding movement of chemical knowledge, that characterized the beginnings of modern chemistry. Let us turn back now to those fascinating periods in which the strivings of chemistry took on an almost romantic phase but nevertheless comprised the periods that made it possible for LeBlanc to do what he did and that make it possible for us to do those things that now are so gloriously advertised.

I think there is a general understanding among readers that scientific chemistry is the successor of an ancient alchemy which sought to produce gold artificially and to explain its occurrence in the earth's crust. In China and also in India from remote times gold was valued as a magic medicine. In Egypt there were expert goldsmiths as early as 3000 B. C. and in the Euphrates valley skilled Sumerian metal workers practiced their craft some 500 years earlier still. Such processes as the weighing and fusion of gold in ancient Egypt were depicted on tomb walls dating back to 2500 B. C. The oldest map in the world which was drawn more than 3000 years ago depicts a gold mining region in the eastern desert of Egypt.

There is ample evidence that the Egyptians were remarkably skilled in various arts based upon chemical knowledge such as metallurgy, enamelling, glass tinting, the extraction of plant oils and dyeing. For such reasons Egypt or Khem, the land of black soil, the Hebrew land of Ham, gave rise to practices variously known as the art of the dark country or the "black art." To Islam this black art became known as Al Khem and through Islam to the Western world as alchemy.

The fusion of Egyptian metallurgical and other arts with the mystical philosophies of the Greeks is often regarded as the true beginning of the science of chemistry which derives its name from the heiroglyphic name for Egypt, supposed to represent a heap of charcoal and a crocodile's tail, and is called chemi with the meaning, black—the black land.

The greatest contribution that Greek thought and Greek ideas rendered to mediaeval alchemy was the introduction of the Four Elements or simple bodies ascribed to Aristotle. Briefly, Aristotle's theory postulated four fundamental properties of bodies: these were hot and moist, with their contraries cold and dry. These qualities pointed to four material elements—earth, air, fire and water, of which all substances are composed. In accordance with the Greek philosophy one body can be transmuted into another by altering the proportions of the elements present. This transmutation was further correlated with the idea of a "prima materia" or primordial matter from which all things come and to which they all reverted. Aristotle called it a fifth element, quintessence. This was a spiritual element which when properly impressed upon any of the others would transmute and change them into any desired substance. It was this weird theory that gave the impetus that sent chemistry rolling down through the middle ages as the black

art of alchemy, the magic of transmutation.

The conclusion reached by an examination of the later writings of the Alexandrian alchemists leads us to believe that all of the Egyptian goldmaking and silvermaking consisted merely in impressing the colors of gold and silver upon the baser metals and that the alchemists of western Europe, by interpreting these terms too literally, were led away on a false trail.

Nevertheless, the ten centuries of alchemy were not useless. Its fundamental concept of transmutation and the hope of accelerating in the workshop the natural growth of a base metal even into a noble metal did not escape the avaricious notice of kings and rulers. With the intangible philosophy of Aristotle and Plato and the obscure reports of the Egyptian Black Art, the royal courts became the abode of the alchemists and magicians that roamed from place to place with the lure and promise of great riches to be gained by transmutation. As already described small pellets of gold and silver like bodies were made in these processes, but to do it on a large scale required the finding of the Philosopher's Stone or Elixir. It was sufficiently plausible and attractive to entice monarchs to finance and protect it within their royal enclosures for otherwise it would soon have ceased to exist from sheer hunger and exhaustion.

The golden age of alchemy reached its sublime heights in the fourteenth century. All of Europe was under the dormant hood of the Dark Ages, under the tyranny of absolute monarchs. No longer was the earth believed to be flat for men had sailed westward and discovered a new land in which was gold for the asking. Copernicus, the monk, was defying the church with his masterly arguments that the earth was not the center of the universe. England was challenging Spain on the high seas. The printing press was invented. Leonardo da Vinci had given the world his masterpieces in both art and science. New masters appeared who refused to follow the myths of their predecessors.

Most notable among the rebelling scientists was Paracelsus who was born the year after America was discovered, the son of a physician and who early turned to medicine He offended venerable professors, ridiculed ancient traditions and attempted to purge medicine of its witchcraft by throwing the books of old masters into the fire. No longer, he declared, would gout be cured by the playing of a flute or sciatica by the blowing of a trumpet. No longer would wearing a monkey's leg cure a monkey bite, or liverwort alleviate liver complaint, or feverwort, fever. To him the human body was a chemical plant to be treated with chemicals. "Seek remedies," he exhorted, "more potent medicines till you find one that will cure all disease." And thus began the crusade for the Elixir of Life that sent Ponce de Leon to the new world for the fabled Fountain of Youth. Now laboratories became not hiding places of secrets, but chambers of mercy and healing. The quest for gold was ended. The period of alchemy was succeeded by iatro or medical chemistry. For more than a century the quintessence of Aristotle appeared in a new guise as the search went on for the one great elixir guaranteed to cure all and sundry ills. Hopeless as the quest for the goldmaking wand has this search proved to be, and in disillusion the early period of chemistry drew to a close about 1650 with but little advance in chemical art beyond that made by the Egyptians. Chemical theory following false gods had moved in circles about an imaginary point.

Nevertheless the awakening was soon to come. The greater actors with their

lines well learned were waiting in the wings to make their entrances. The prelude was over. Chemistry with its transforming power advanced boldly on to the stage to take its place with the world's great forces. The drama of modern chemistry is still on the stage. The older actors give way to the younger, but who pay tribute to the older, ever.

In a recent address to the graduating class of Stevens Institute, Professor Lawrence of the University of California described his work that deals with the artificial radioactivity of common table salt. After calling attention to the fact that there are scienific cycles just as there are business cycles, he says: "We are now on the threshold of a new era fraught with potentialities for the future—the new era of the atomic nucleus. The new frontier lies within the hearts of atoms and we are in a position to attack the problem the ancient alchemists set for themselves. Indeed their dreams have already been surpassed, for they sought ways of turning base metal into gold, while the modern scientist is now making something vastly more precious and useful—the artificial radioactive substances."

The demonstrations which Professor Lawrence has been giving in his public lectures with ordinary table salt made artificially radioactive has amazed even his calleagues. The important contributions to medical science that are in prospect make us think that perhaps salt has at last regained its savour and that quite properly only the outstanding persons may be called "the salt of the earth." No greater proof of the continuity of science is needed perhaps than to point to the healing activated salt of Lawrence, to the beginnings of chemical industry by LeBlanc and to the allegorical use of salt by the Great Teacher to typify that which is noblest and best in all human life.

There is another great tribute that modern science is paying to the alchemy of antiquity. It is the recognition of the four elements of Aristotle as the source of all wealth. This earth consists of rock and soil, air and water, and it receives its energy from the sun. From these we get our living. In them is contained all our wealth. Chemistry simply describes how these four components of nature may be transformed from their existing forms into others which we may desire or enjoy much more than their natural state. From ordinary air we extract small traces of a substance, neon, which we use to influence the transfer of millions of dollars from one pocket to another in so-called advertising signs. In the water of the oceans there is enough gold in solution to provide a $1,000,000 for every inhabitant of the globe. The energy of the sun lifts the water from the ocean in the form of vapor which floats to the mountain tops where it falls as snow and is stored for a season until the energy of the sun again changes it to water, which in falling from the high land to the low land, may be converted into the hydroelectric power which lights our homes, cooks our meals, carries our messages to the ends of the earth, and performs a multitude of tasks that once were the burdens of human slaves. We have learned even how to convert this energy into matter or commodities that may be packed in barrels and sold in the markets of the world. From water, air and electricity we can now make chemical compounds for use as explosives, dyes, and fertilizers.

Air, earth, water and sunshine are the four horsemen of a chemical revolution that has promise not only of increased comforts for our daily lives, but holds forth much for a greater stability in our social and economic conditions. It is in the alleviation of unfavorable conditions in industry and agriculture that a new movement has

called science into service in behalf of mankind. This movement is known under the name of Chemurgy—a newly coined word made up of the Egyptian chemi and the Greek word, ergon, meaning work. Chemurgy, therefore, means the work of chemistry, and in its specialized meaning it deals with the application of chemistry to the annual crops as raw materials in industry.

The application of chemistry is not a spontaneous affair. It does not naturally occur. It is at this point that our modern methods of instruction and research step on the stage. The reactions of the LeBlanc soda process had been known for a long time but he was the first person that with deliberate intention and for a practical end changed salt into soda, with his eye not only on chemistry but on economics as well. And he accomplished much more than he expected. Chlorine products and cheaper sulfuric acid resulted. Instead of making soda for the glass industry, another new industry with cheap alkali now was established for something that hitherto had been a luxury enjoyed only by the rich—this product was soap. Thus LeBlanc was responsible for a cleaner world, and through the use of cheap soda in the textile industry, a whiter world.

There are other considerations in the application of chemistry to industry—those of obsolescence of industrial upsets. LeBlanc's large scale manufacture of soda diminished the use of perfumes and incense and of any other business that prospered because of a lack of soap. Finally LeBlanc's soda process was flung on the rubbish pile for the cheaper methods now used and, most amazing of all, we now have soapless soaps which require no alkali at all in their manufacture.

What I have tried to develop in this discourse is patience in the study and understanding of chemistry—a regard for the toil and labours of that great host of men and women whose work is enshrined in the literature of our science and to which we may turn for almost every condition of perplexity that may be encountered. This is the work of the colleges and universities.

My second objective was to show the necessity of direction. We cannot have a French Academy or a British fleet to bring about the application of chemical knowledge in the affairs of our daily lives. It is significant that spontaneous movements such as Chemurgy, and legislative bodies such as state planning boards, and philanthropic institutions such as the Mellon Institute have sprung into existence and are marshalling the academic facts of science into the channels where they will feed the social and economic necessities of the day.

In the Pacific Northwest we have need for the pioneering of science in behalf of our industrial development. The application of chemistry to our forest resources is urgent. The utilization of trees has thus far been mechanical consisting of the reduction of trees to logs by logging and to boards by sawmills. These industries utilize roughly about one third of the tree as it stands in the forest, the other two-thirds consisting of logging and sawmill waste. The chemical utilization of wood offers a more efficient method in the use of wood. By mechanical reduction to chips and the use of chemical reactions for pulp manufacture the loss is reduced to 50 per cent consisting largely of lignin, the chemistry of which is still unknown. Fundamental research into the nature of the lignin molecules is under way in this and other countries and must be awaited for more complete utilization of the wood used in the pulp industry. Other chemical reactions applied to wood as a raw material are promising, resulting in the production

of plastics for structural and housing purposes as well as the production of carbohydrates convertible into fuel for automotive transportation and other uses.

The development of hydroelectric power offers an opportunity for the application of the energy of falling bodies of water into commodities. From water, air and electricity ammonia and nitric acid may be obtained in forms convenient for packaging and marketing in other parts of the country or the world. Electrochemical industries manufacturing phosphates, carbides, light metals, fertilizers find an attractive habitat in this region. Acres now idle beckon to the migration of peoples from the drought sections and the marginal lands and assure us a population ample to consume the products made by chemical processes.

In the western part of this State are coal deposits of large magnitude which are but slightly utilized as fuel due to the greater convenience of oil as a heating agent for homes. When chemistry is applied to the coal industry this picture changes completely. When coal is heated under pressure in the presence of hydrogen and a solvent it is possible to change the solid organic matter of coal to a liquid and pump it 500 miles or more in pipe lines as fuel for steam engines or in the cylinders of Diesels or for use in house heating. Coal hydrogenation due to the abundance of petroleum resources has made but little headway in this country, but in Germany, England and Japan the process has already begun.

In summarizing this discussion, I have borrowed freely from the history of chemistry and of science to show how essential is the teaching and learning of the facts of science; our indebtedness to that vast literature recording the patient labors of the scientific workers of the past; the great need of intelligent direction of the facts of chemistry and of science so that they may be marshalled into a line of duty for service in industry. When this is done, there comes back to us a multitude of things which transform the conditions under which we live; that add to our social and economic stability; and constitute an enlightenment of modern life attainable in no other way.

[In the preparation of this address the author is especially indebted to Read: Prelude to Chemistry; MacMillan (1937), and French: The Drama of Chemistry; University Society Inc. (1937).]

Sidelights of Gunpowder Traffic in the Northwest Fur Trade

By ALBERT J. PARTOLL
University of Montana

(Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 29-30, 1936)

Sidelights of gunpowder traffic in the Northwest fur trade present an interesting array of incidents and facts concerned with the economic, sociological and historical changes in the civilization of the west for the fifty years from 1805 to 1855.

No other single item of trade with the exception of spiritous liquors and perhaps the steel trap, had such consequential effect upon the whole history of the frontier of the Pacific Northwest, as gunpowder, and the means of using it, namely firearms.

Gunpowder, the small granules compounded of sulphur, saltpetre, and charcoal, was the source of friendship, hatred, tribal warfare, game destruction, and loss of aboriginal independence. Destructive in its very nature, the gunpowder and "boom-stick" as the Indians called the rifle and other firearms, announced in explosive terms the passing of the primitive life and independence of the natives and the dawn of a new era.

Fifty years is not a long interval of time in the story of the world, yet in that period of transition, a great expanse of territory was to become definitely the possession of the white man, not as the tyrannical warlord, but rather as the helpful trader in merchandise especially firearms and gunpowder. The price paid for the white man's "villainous saltpeter" was not in the peltries of trade, but in the shift from independence on the part of the natives to one of almost absolute dependence upon the white man for weapons of defense and instruments for hunting.

Almost unnoticeable at the beginning, this new era of gunpowder was one of the most decisive in the history of the American nation. The conquest of the western wilds had begun in a manner unlike that of the warring invader. This indirect invasion was not to show itself as such for a half century, when its great undermining influence was to appear in its real significance.

Having thus in a general manner introduced the subject of the significance and consequences of the trade in arms and explosive gunpowder, it is well to note how this "epoch of transition" was begun. In this regard it is appropriate to say that the great changes in warfare and hunting brought about by the introduction of firearms and gunpowder in European affairs several centuries ago, finds an interesting parallel in the period of Northwest history now in consideration.

To Lewis and Clark of the famous western exploration of years ago, belongs the distinction of introducing into the interior of the Pacific Northwest, the first firearms and gunpowder. On their memorable expedition in the years of 1805 and 1806 in the far west they depended upon their firearms and skill to use them, to supply fresh meat. Their hunters, notably Drewer and Colter, were experts with the rifle and brought down large and small game.

Suspiciously and somewhat in awe the feats of the white visitors were watched by the Indians, who immediately became aware that the white man's thunder brought down game far beyond the range of efficiency of the bow-and-arrow. Ownership of such power and "great medicine" would mean much to any tribe and add prestige to the individual owner. Tribal

councillors and experienced chiefs realized that the ways of the white man were dominant in case of war, and that firearms would mean added strength to Indian warriors.

To a large measure the explorations of Lewis and Clark prepared the way for the coming traders and trappers, who were to bring arms and ammunition, by acquainting the Indians with this the superior instrument of destruction in hunting or warring.

Although traders and trappers were willing to pierce the unexploited rocky mountain regions of the Pacific Northwest, the actual establishing of trade in firearms was not easy to accomplish. It was not the rugged mountains, dangers from occasional foes in ambush, the threat of food scarcity, or other economic reasons, which blocked efforts to establish trade with rocky mountain Indians. It was the deliberate protest from eastern tribes, notably the Piegans, that the traders should not supply western Indians with firearms. The Piegans realized that should the traders penetrate successfully west it would mean that no longer would the mountain tribes be confined primarily to that region, but they might openly and defiantly challenge their eastern opponents.

David Thompson of the Northwest Company is credited with opening trade relations in the interior of the Inland Empire of today, when in 1809 he successfully established the "Kullyspell House" on Lake Pend d'Oreille, and "Saleesh House" among the Flathead Indians. Subsequently his efforts were to meet with competition from the Hudson's Bay Company which established Howes House in the region, and also from the Astorians of the Pacific Fur Company, which organization also founded a post in the same region, a few years after Thompson.

But to Thompson and associates must go the distinction of having blazed the commercial traders' trail to the upper waters of the Columbia, by penetrating from the east the rocky ranges, and exploring with the view of establishing posts, the almost entire length of the present Clark's Fork of that river, to the Pacific ocean.

Even as early as 1807 the Piegan Indians retarded Thompson's westward movements when he was seeking the headwaters of the upper Columbia. Thompson was successful in his undertakings, and so it is not necessary to here review the career of this great man who was undoubtedly one of the west's greatest explorers. His career is deserving of special consideration.

Thompson made history when he established his two posts in 1809, and escaped the vengeance of the Piegan Indians when he opened trade with the western Indians. He won the loyalty and friendship of the Flathead or Selish Indians and their allies, the Kootenai and Kalispell Indians, by bringing to them the most revolutionary of defensive weapons, firearms and ammunition. From that time on warfare in the west took on a changed aspect; the introduction of gunpowder changed history.

Alexander Henry, an associate of David Thompson, in his manuscript of those memorable years, gives an interesting summary of the situation when he states:

"Formerly, all those tribes became an easy prey to their enemies, having no other weapon than the bow and arrows. But within a few years they have learned the use of firearms and acquired supplies of arms and ammunition from us, thus becoming formidable enemies whom the Slaves (Piegans) can no longer attack with impunity; though the latter still steal the farmer's horses in great numbers.

"The first severe check the Piegans

ever received from the nations on the waters of the Columbia was in the summer of 1810, when they met the Flat Heads and others marching to the plains in search of buffalo. The meeting was so sudden and unexpected that the Piegans could not avoid giving battle. They fought with great courage nearly all day, until the Piegans had expended their ammunition and were reduced to defend themselves with stones. A small rising ground which divided the two contending parties enabled them to come to close quarters. At last the Piegans were obliged to retreat, leaving 16 of their warriors dead upon the field. This defeat exasperated the Piegans against us, for strengthening their enemies by supplying them with arms and ammunition. They fain would wreak their vengeance upon us but dread the consequences, as it would deprive them in future of arms and ammunition, tobacco, and above all, their favorite liquor, high wine, to which they are now nearly as much addicted as those miserable tribes eastward."

Elsewhere in his manuscript Alexander Henry notes that the Columbian brigade left Rocky Mountain House in October, 1810, destined for the Flatheads, but was repeatedly stopped by the Piegans, "who having been severely defeated last summer by the Flat Heads, were determined to cut off the latter's supply of arms and ammunitions, and had kept a strict watch for that purpose."

This is not the sole example of its kind in the story of the great Northwest in the days when the fur trade was at its greatest importance. Similar incidents are recorded in the history of Fort Union, and also in the explorations of Fremont, each of which will be given a note of consideration to show the influence of the trade in gunpowder.

Fort Union in the Upper Missouri region was beseiged in the early summer of 1834 by Crow Indians, who sought to destroy this post of the American Fur Company for supplying their enemies with arms and ammunition.

Chief Rotten Belly of the Crows was the leader of the besiegers who encamped about the fort, just beyond range of the rifles of the traders in the fort. The Crows felt confident they had the siege well under control since they had run off the horses of the fort, to prevent any attempt to ride for help.

After several weeks the situation became critical in the fort with no immediate relief in sight. No shots were exchanged at damaging ranges, and the Crows showed no signs of either attacking the fort or leaving. Peace and watchfulness seemed to characterize the conduct of the Indians.

Fearing dire consequences would result unless some measure of relief were taken, the commander of the fort, Major Alexander Culbertson, planned to either end the trouble or make it a fighting issue. In these plans a cannon used by the fort chiefly for salutes was to play the leading part.

A shot from the cannon, carefully aimed, zoomed into the Crow camp. Into a stampede and scamper for horses went the besiegers, who were not prepared for this new tactic of defense. The long range of the cannon, the loud noise, and the large cannon-ball broke down the morale of the Crows and the siege was over.

Thanks to the cannon, the Crows learned they must accept as inevitable the gunpowder and arms trade of the fort, even though their enemies might profit thereby.

As late as July, 1844, John C. Fremont in charge of his noted western explorations encountered adverse sentiment on the part of the eastern Indians who believed he was assisting other Indians of the west. He notes in his "Memoirs" that while visiting a village of Arapa-

hoes in the bottoms of Grand River:

"About twenty Sioux were with them --one of them an old chief who had always been friendly to the whites. He informed me that, before coming down, a council had been held at the village, in which the greater part had declared for attacking us—we had come from their enemies, to whom we had doubtless been carrying assistance in arms and ammunition, but his own party, with some few of the Arapahoes who had seen us the previous year in the plains, opposed it."

"It will be remembered that it is customary for this people to attack trading parties which they meet in this region, considering all whom they meet on the western side of the mountains to be their enemies."

Piercing well into the interior of the Rocky Mountains were two great waterways, the Missouri and the Columbia. By these streams it was possible to transport merchandise including arms and ammunitions to the trading posts and forts, and also to ship out furs and other items received in exchange. By a direct line of navigation it was possible to bring merchandise from St. Louis several thousand miles into the region of the upper Missouri for posts there. By a similar line of navigation of the Columbia it was possible to serve posts on the western slope of the mountains of the Pacific Northwest.

The line of the Missouri River was used principally by the American Fur Company and the Columbia by the Hudson's Bay Company, which firms were the chief traders in arms and ammunition of the Pacific Northwest, as well as the source of supply of other trade goods.

Following its absorption of the Northwest Company in 1821 the Hudson's Bay Company organized a system of trading throughout the interior of the Pacific Northwest covering for the main part present day states of Montana, Idaho, Washington and Oregon. In the wilderness of that time were located forts to take care of local trade in furs and to serve as collecting places and outfitting stations.

These Hudson's Bay posts were supplied with their trade merchandise from the ships on the Pacific Coast, by the waterway of the Columbia. Kegs of gunpowder, bags of shot and rifle balls, and firearms were among the trade articles as well as iron arrow-heads, and the trinkets of personal adornment for catering to the desires of flashy and picturesque warriors.

Interesting testimony is offered concerning the importance of the Columbia as a waterway of trade, by Chief Factor Dugald McTavish of the Hudson's Bay Company, who in 1866 reported that:

"As far, therefore, as it would answer this important purpose, the line of the Columbia River was used as a means of communication to the interior; thus, on leaving Fort Vancouver, we proceed up the river some two hundred miles, and we reach Fort Nez Perces, or Walla Walla, situated on the left bank; this itself was a place or depot for goods to be sent overland to the Snake country, and for furs to be brought out too; we then proceeded up the Columbia river some two hundred and fifty miles further, when we land at Okanogan, on the right bank, where all the supplies for the interior districts, known as New Caledonia and Thompson's River, are stored for transport by horses to their destination, and the furs are also brought there to go down the river.

"Continuing up the river some two hundred and fifty miles, we reach Fort Colville, on the left bank of the Columbia, where the supplies for the Kootenais and Flat-Heads are landed and sent on. From all this it will be seen that the three posts mentioned, Nez Perces, Oka-

nogan, and Fort Colville, apart from their value as places of trade, were also of primary importance to the business in their connection with the districts above stated, say the Snake country, Thompson River, New Caledonia, and Kootenais, and the Flat-Heads, as without connection between them, the communication between the depot and the interior generally would have been so imperfect as to have prevented the business working well or smoothly.

"The Columbia river was also a necessity, as, in order to keep up the communication between Fort Vancouver and Hudson's Bay, the river was used above Fort Colville some two hundred and fifty miles, to a point in the Rocky Mountains, known as Boat Encampment, where the Company's people left their boats and crossed the mountains on foot or horseback, as the season of the year permitted."

Gunpowder and firearms were guardily traded at the establishments of the Hudson's Bay Company, for reasons of precaution and discretion, in contrast to the policy of many other trading companies who cared little about the general after effects of unrestricted trade. The company favored trade for general merchandise, and did not encourage catering solely to hunting and warfare interests of the men of the tribes at the expense of the women and children, who unquestionably were entitled to some consideration in tribal welfare.

At the fur trade rendezvous of certain American traders from the east, held annually during the boom days of the fur trade of the 1830's at Green River and Wind River, most of the business was concerned with the objective of quick negotiation. Traders and trappers seemingly cared little about the consequences of unrestricted firearms traffic because they could leave before the effects of unbalanced trade were in operation. The favorite overland route to the rendezvous was by the Oregon trail, by which kegs of powder and bundles of merchandise were transported by pack horse, although sometimes steamboats brought cargo far up the Missouri when it was again packed for the trip to the trading places.

Gunpowder and firearms were favored items because hugh profits were possible; although liquor was a bigger profit maker it must be remembered that it was on the illegal trade list. Firearms and the accessories of powder horns, shot, lead balls and pouches would buy anything from furs to horses and equipment to transport traded goods out of the wilderness. The wise trader relied upon this demand and stocked his goods accordingly.

In outstanding contrast to the conservative policy displayed at the Hudson's Bay Company posts, trading at the rendezvous was often an orgy of human nature at its worst. Liquor and cut alcohol flowed freely for those who cared to imbibe. Gambling existed without restraint, and the main idea seemed to be to get the most out of the trade carnival in furs, goods and dissipation. Without doubt competition had a marked effect upon business at the rendezvous where a conservative policy might mean loss of profits.

Traders were sometimes not adverse to playing a joke upon the Indians. Perhaps it was in reprisal for some robbed cache, or raid upon hidden supplies or theft of horses, that led to this action.

There is a story that some traders informed a band of Piegan Indians that if gunpowder were planted like wheat it would reproduce itself in great quantity. The deception went undetected until the Indians wondered why their crop should not give some evidence of at least starting to grow. Investigation revealed the deception and the traders and trappers did not increase their popularity as competent advisors.

An Indian party approaching a trading post or a band of trappers was expected to fire a salute into the air to denote peaceful intentions. This salute was often returned by the party approached as a sign of mutual acknowlegement. Powder was a required asset to carry on this practice, an an offering of a horn of powder sometimes accompanied the meeting of the two parties, depending upon who was seeking the favor of the other.

John Work and Alexander Ross, traders for the Hudson's Bay Company, were aware of this custom and won friends in this manner. Ross in 1824 carried a small cannon with his expedition in the Northwest, and honored leading chiefs with a salute from "the big gun." Unfriendly Indians gave wide berth to any party having a cannon, and to this attitude Ross attributed much of his trader's luck.

Possession of firearms by the Indians in some ways promoted war, since longer range and more damaging effects were possible than with the bow and arrow. More time was available for war and hunting because the long time required to make a good outfit of bows and arrows, was eliminated. Purchase of firearms and ammunition was a matter of brief transaction with traders.

Tribal behavior determined whether firearms would be allotted to a respective tribe. Some tribes dared not be warlike lest they forfeit trading privileges, and their enemies become too well armed. As an instrument for lighting fires the firearm was unexcelled and this feature of gunpowder traffic also received tribal consideration.

The advent of gunpowder was of far greater influence in tribal life than is generally realized. In addition to some of the points already considered, the evidence given by Alexander Ross and Doctor Richard King is worthy of con-

Ross, while at Spokane House in 1814, sideration.

was informed by an Indian chief that the white man had made the Indian love tobacco, and since the Indians had secured firearms they had almost forgotten how to use the bow and arrow.

From the statement of Dr. King to the Hudson's Bay Company in 1857, this self-explanatory paragraph is borrowed:

"In the first place they have lost their original mode of hunting; the use of the bow is gone, the gun having been placed in their room, by which they become dependent upon the Company for their powder and shot. To make an Indian really a hunter with the bow and arrow, a deer-stalker, takes a whole life to learn to approach at that distance for which the bow and arrow come into use."

Sidelights of gunpowder traffic in the Northwest fur trade here presented are intended to show how influential was the actual trade in this explosive substance. It is self-evident that gunpowder and firearms were responsible for many changes in the economic, sociological, and historical aspects of frontier life in the interior of the Pacific Northwest, for the period considered (1805-1855), when the fur trade was at its height. History after that time is concerned with the era of settlement, for which the fur trade, with its commerce in gunpowder, blazed the trail.

Practical Aspects of Public Health Education

By RICHARD A. KOCH, M. D.
County Health Officer, Whitman County, Washington

With the great advance of the activities of public health in the western states during the last ten years, the quesion arises as to the training necessary and the training facilities available for the nonmedical personnel of public health departments, namely sanitarians and milk sanitarians. In the larger city health departments the various phases of public health, under the jurisdiction of the health department, are segregated into different divisions with qualified personnel handling each separate division such as general sanitation, water and sewage inspection, food inspection, meat inspection, milk inspection, sanitary engineering and quarantine work, etc. However, in the rural areas with small county health departments it is necessary for these functions to be handled by a small group of nonmedical public health workers, consequently the question arises as to what type of academic training is most suited for this type of worker. If a sanitary engineer is employed he of course is deficient in such training as is necessary for meat inspection, milk inspection, food inspection and quarantine work. Vice versa, if a veterinarian be employed his education is limited so far as sanitary engineering would be concerned. It is apparent, therefore, from this consideration that there is a considerable need for the training of individuals who have a broad aspect of public health work, namely the training of sanitarians, which, I believe, is a collective term that should be used to designate those members in the public health field who are engaged in the nonmedical aspects of the public health program.

With this point in mind it is well to consider the statistics available so as to determine the actual need of public health personnel in comparison to the number of workers which are now in the field. Let us consider the western states of Arizona, California, Idaho, Montana, Nevada, Oregon, Utah and Washington. In 1915 there were three full time county health departments in all these western states employing one public health nurse and one sanitary inspector, as they were then called. At this time $25,358 was being expended on rural public health by these three county health departments. By 1920 there were nine full time county health departments in this field with a nonmedical personnel of 28 public health nurses and 13 sanitary inspectors, expending a total of $146,284 a year. By 1925 these figures increased to 23 full time health departments with 103 nurses and 62 inspectors, expending $1,001,761. In 1930 there were 40 rural health departments in the field employing 143 public health nurses and 67 inspectors, expending $2,189,620 a year. Last year, 1936, these figures had increased to 45 County Health Departments employing 168 nurses and 124 inspectors.

The figures for 1937 are not as yet available, but with the great stimulus that has been given to public health through the assistance of the United States Public Health Service it is not amiss to venture that these 1936 figures have been greatly extended through the last year.

Now that we have made an analysis of the present situation as to full time county health departments let us look into the actual needs of the field in this area. The western states mentioned contain 276 counties. These are all in need of full time county health depart-

ments, however, because of the small population existing in some of the counties, especially in Montana and Nevada, it is not feasible financially to have one full time health unit serving each county, therefore, the policy must be inaugurated to have full time county health districts serve two or more counties.

Figuring collectively, therefore, one may say that there is a need of approximately from 200 to 225 County Health Departments in this area. At the present time as previously stated we have 45 full time County Health Departments. This gives us a need of an additional 150 to 175 full time County Health Departments necessary in this area. Figuring proportionately from the nonmedical public health workers employed by the existing departments we find that each department is employing on the average of 3.7 public health nurses and 2.7 inspectors or sanitarians, consequently if we are to have 175 more health departments, figuring proportionately, there is a need for 647 more public health nurses and 472 more inspectors. Putting these figures on a percentage basis we find that at the present time the western states are only served by 16.3 per cent of the total public health nurses and 16.3 per cent of the number of sanitarians and milk sanitarians which would be required if these areas were fully served by full time county health departments. It is quite obvious then that although the interest in the activities of public health has come a long way since 1915 there is still a great need for continued progress in the development of new and as yet unserved areas.

Where is this personnel to be obtained? At the present time it is most difficult to procure any additional public health nurses, and men trained in the field of sanitation are almost nonexistent, consequently it is the duty of the universities and colleges in this field to provide courses for the training of this personnel.

As far as I am able to determine the only attempt to meet this need at the present time is the School of Sanitation which has been established at the University of California, but surely one institution of this kind is not sufficient to satisfy the needs of this great area, therefore, we must promote the interest of educators in this field so as to establish schools of sanitation for the training of sanitarians in this area. Although there is a need for many additional sanitary engineers and veterinarians in the field there is a more dire need on the part of these rural health departments for sanitarians who have a rounded education in the collective field of sanitation. I believe that a satisfactory segregation of training courses would be as follows:

1. Sanitary Engineering.
2. Veterinarians who can serve both as meat inspectors and milk sanitarians.
3. Sanitarians who have a rounded educational background involving the fields of general sanitation, food inspection, water supervision and sewage disposal supervision.

I feel that we here in Washington should have such courses available for the training of this personnel.

Land Values in Relation to Soil Conservation

By WARD K. NEWCOMB
Vice President, The Federal Land Bank of Spokane

Land values reflect man's appreciation of the privilege of using, controlling and owning a particular part of the earth's surface. Theoretically, this ownership extends upward and downward as far as he chooses to use it. However, for practical purposes the use is generally confined to a comparatively thin layer of soil. It is upon this layer of fertile loam that our existence depends. It sustains all life as we know it, and is, therefore, the most important of our resources. Its value to mankind transcends any monetary standard. If this thought is kept in mind, it will help to explain the public interest in conservation. Whether you or I own land or not, or whether we ever produce any of its sustaining growth, is immaterial. Our interest in its conservation as a means of perpetuating the human race and our civilization is the same.

But for convenience in trade there is established a more or less flexible consideration expressed as a price which willing buyers and sellers accept. This price is a measure of the value of its use and control, subject, however, to such restrictions and privileges as the public may from time to time impose or reserve. These values may therefore, be affected by many changes, including monetary standards, economic conditions, etc., but chief of these is an alteration in the manner of its use. In the Northwest we are particularly susceptible to this change for a number of reasons. Ours is a comparatively new country across which settlement proceeded mainly without scientific guidance and with the ever-present thought of limitless opportunity. Pioneers approached the agricultural problems of new homes with established habits of land use. Their conceptions of soil and climatic responses reflected former environment. It may be said also that pioneer stock is less conservative and more given to speculation and expansion of operations than are those who stay in the ancestral homes. It is these characteristics which impel pioneers in their quest for new locations with wealth untouched by the hands of man. The more easily converted resources of a new country tend to stimulate and distort figures as to its normal abiiity to produce a dependable income without depreciation. Under the impulse of the profits of this conversion, depreciation is capitalized, values rise, money flows freely and credit for further exploitation is extended upon a liberal basis. As resources are exhausted, or it becomes more difficult to convert them, periods of stringency and readjustment are inevitable. Depleted fertility, exhausted mineral resource, denuded timber lands, ever increasing flood hazards, vanishing water supply, and other evils, due to lack of proper use, begin to become apparent in diminishing returns, lower standards of living, and hastening poverty, both for the owners of the land and those who supply them with goods and services. Enterprise is starved and general bankruptcy may ensue. Our land has been a long time in the making. The process of ages has depended upon continual balance between plant and animal life. Over-use or abuse of the land quickly resulted in elimination by starvation to the point of balance. We have every reason to observe this inexorable rule of nature. Any definite progress must result from the establishment and maintenance of this balance. A great national interest exists, for it is a fact that in the long

run citizens maintain about the same relationship with a government and its institutions which they enjoy from the natural resources of a country. To strengthen the foundation of these resources, particularly agriculture, is to stabilize society.

Conservation may be defined as intelligent use, and in the case of our land resources, carries with it the implication that such use should leave the land improved, or at least unimpaired. This is a point which gives our Land Bank Appraisers much concern. In the making of long-time loans upon land, some of which run for a period of 33 years, it is of the greatest importance to be able to discern with a degree of accuracy, the productive capacity of the security during that period. The extent to which the owner is selling his farm when he hauls his wheat to the warehouse or delivers his live stock to the buyer must be considered.

In order to apply the conception of intelligent use, it is necessary to limit its use in such a manner as will curtail the profits of exploitation. In the case of an ordinary farm, a well conceived plan of conservation usually implies a diversification and balance in operating detail which not only tends to stabilize the operation financially, but very often increases the immediate cash income. Were it possible to discuss conservation in terms of an individual farm, its effect upon values would be simple for the reason that most individuals readily translate so evident a form of permanent security and independence into that relationship between life and environment which is measured in values. But the problem is not so simple.

A given problem in conservation may involve a farm, a local community, an area of similar soil types, a watershed, or a region subjected to common climatic conditions. It follows then that the individual may be affected to various degrees by all of these problems. The extent to which we may be brought to realize this interdependence of intermingled groups will measure the scope and force of our efforts. Conservation of land resources on a national scale is a long-time program with an intricate and complex pattern and cannot be viewed as a temporary problem which will yield to the application of haphazard remedies. It is a healthy sign to find an awakening national interest in this subject and I am glad this scientific body has deemed it of sufficient importance to merit its active study and consideration. A proper public participation in conservation requires the coordinated treatment of entire regions affected by common problems. It may best be effectuated under our democratic system of government by the creation of autonomous legal machinery under which the necessary leadership and management will develop. National conservation must be inculcated in our laws, institutions, and habits.

Now the point this paper is supposed to treat, is the effect which conservation has or will have upon land values, and I presume this means as they are reflected by our present conceptions which I think I may state, are far from clear. This effect, I think, may be measured approximately by two factors. First, the extent to which our present conception is based upon an excessive and improper use of a land resource, and second, the extent to which we may restore or create a greater degree of usefulness consistent with the maintenance of a natural balance. To illustrate the first factor, if our conception of the value of grazing land is based upon an assumed carrying capacity which will eventually eliminate palatable and nutritious grasses, our value is too high. If we value wheat land for its ability to produce one crop after another, while

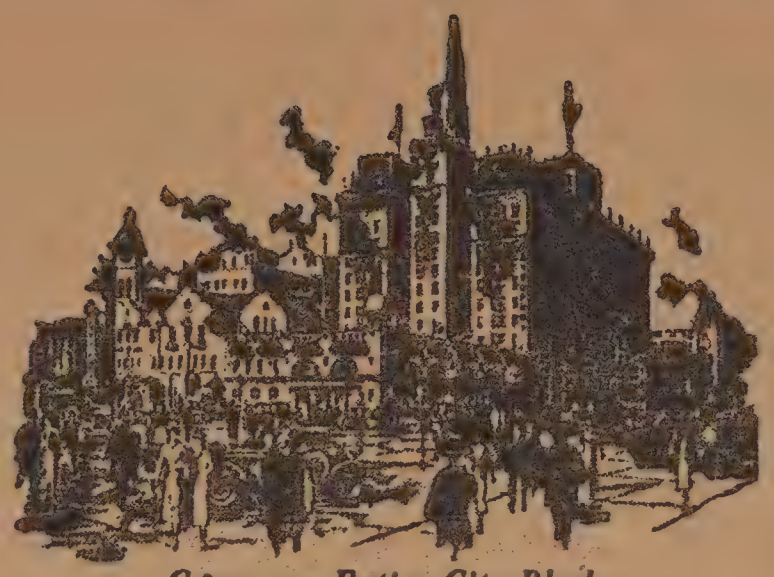
the essential ingredients of fertility are diminishing and erosion is hastened, that value is too high. If timber land is valued for what can be immediately gained by destructive methods of logging, rather than upon a plan of sustained production, it is too high. In all these operations we make the common mistake of capitalizing depreciation, but the greatest mistake is doubtless the lack of appreciation as to the effect this will have upon our future operations. It is a fair assumption that as a nation, we are now being brought to a realization that in such cases of abuse balances must be restored, that nature's methods of retaliation are certain and inexorable in relation to disturbances which result from exploitations of this character. So long as we had seeming limitless roo mfor expansion the difference between development and exploitation was not so clearly apparent but having observed these evils we must now be definitely committed to a program of better use and conservation of all natural resources. It is the policy of the government in the public interest to retire in excess of one hundred million acres of land from private ownership and subject it to restorative treatment. Much of this land has been settled upon the mistaken assumption that the soil and climate were sufficiently favorable to support crop production. In the correction of this mistake the land must be put to other uses so that a natural balance will be established and maintained. The real value, therefore, of this land may be considerably less than that which has been commonly accepted. While the losses in dollars, which have been and will be sustained by this necessary change in land use, amount in the aggregate to a tremendous sum, they are as nothing when compared with the human disappointment and suffering inflicted by the chronic maladjustments which have resulted from its misuse.

The second factor, however, in which conservation may change values, presents a more hopeful picture. This contemplates the extent to which we may create a greater degree of usefulness consistent with the preservation of a balance. And the field for such development seems almost unlimited. In fact, most of the processes which are essential to the removal of former abuses seem to be identical with a type of conservation which must be employed in the reclamation and development of still greater usefulness. This type of development should be expanded to its limit. As an example, let us consider the proper storage of water and its diversion for irrigation of arid land. This storage does not involve dikes and dams alone, in fact these may be considered of minor importance as compared to the restoration of vegetative covering which has a tendency to fill that greatest of all natural reservoirs, the soil.

To the people of the Northwest, this type of conservation leads in importance. But I think we should realize the breadth of the problem. Many instances have come to our attention where the developers of irrigation thought that they had concluded the project when the diversion dam had been built and the ditches dug, only to be confronted later with a diminishing water supply, silting of their system and in some cases disastrous floods. The permanency of better uses established in this manner, therefore, depend upon the maintenance of the water table in the entire shed. To restore and maintain a supply of ground water is chief among our problems, and this restoration and maintenance involves many forms of conservation not yet generally realized or practiced. In a broad general plan to reestablish and improve this resource, it may seem to some individualists that legitimate opportunities are restricted.

But these interests must give way to general welfare in furtherance of the entire scheme, to the end that, fertile soil, wherever available, may be brought to its greatest ability to serve our long-time needs.

I feel therefore, that we may conclude that land values in relation to soil conservation depend for their permanence and stability upon the degree of accuracy in our conception of the best use of the land and the extent to which such proper use affects the ability of the land to serve the needs of men in a sustained and balanced program.



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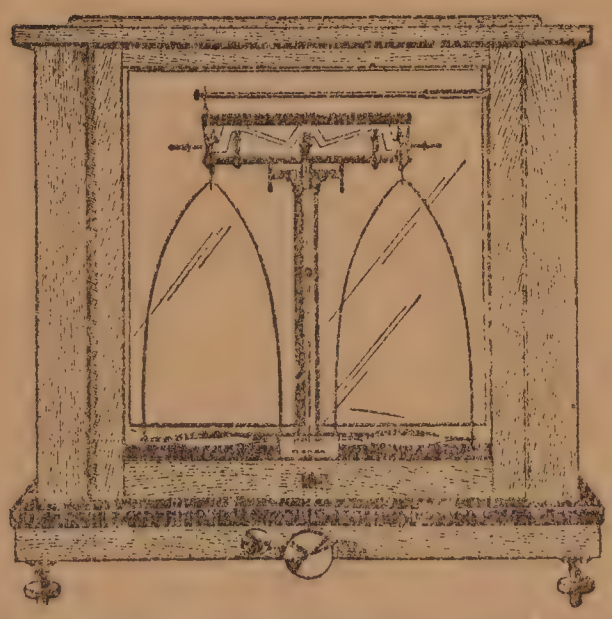

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San Diego Meeting of A. A. A. S.

The Pacific division of the American Association for the Advancement of Science and its associated societies will hold its 22nd annual meeting at San Diego June 20th and 25th, under the auspices of San Diego State College, Scripps Institution of Oceanography, San Diego Museum, San Diego Society of Natural History, Zoological Society of San Diego, and San Diego County Medical Society.

Most of the meetings will be held in the Natural History Museum and other buildings at Balboa Park. General sessions on Tuesday morning, June 21st, will be devoted to a symposium on "Climate and Man." Two of the speakers will be John B. Leighly, University of California, on the "Present Climate of California," and Merrill K. Bennett, Stanford University, on "Climate and Agriculture." On the afternoon of Tuesday reviews of current research will be presented by J. A. Anderson, Mount Wilson Observatory, on "Recent Instrumental Developments in Astronomy"; by H. U. Sverdrup, Scripps Institution of Oceanography, on "Recent Advances in Our Knowledge of the Oceans"; by C. H. Danforth, Stanford University, on "The Sex Hormones"; and by R. Goldschmidt, University of California, on "Genetics." Tuesday evening there will be a symposium on "Animal Experimentation," and Wednesday evening Dr. J. S. Plaskett, President of the Pacific Division, A. A. A. S., will speak on "Modern Conceptions of the Stellar System." Among the Societies presenting programs at the meeting will be:

American Anthropological Association
American Association of Economic Entolologists
American Association of Physics Teachers
American Chemical Society
American Meteorological Society
American Physical Society
American Phytopathological Society
American Society of Ichthyologists and Herpetologists
American Society of Plant Physiologists
Association of Pacific Coast Geographers
Astronomical Society of the Pacific
Botanical Society of America
Ecological Society of America
Oceanographic Society of the Pacific
Pacific Coast Entomological Society
Society of American Bacteriologists
Society for Experimental Biology and Medicine
Western Society of Naturalists
Western Society of Soil Science

According to present plans the 1939 meeting of the Pacific Division of the A. A. A. S. affiliated societies will be held at Stanford University June 26th to July 1st, 1939.

MAY 31 1938

Need for Research in the Field of Hydrology

By O. W. MONSON
Irrigation Engineer, Montana State College, Bozeman
Presented to Meeting of the Soil Conservation Section, December 29, 1937

Hydrology has been defined as "The science treating of water; its properties, phenomena, and distribution over the earth's surface." In connection with the U. S. Geological Survey, the term is used in a specific sense with reference to underground water sources as distinguished from hydrography, which is applied to surface water supplies and sources.

The term is used in this paper in a broader sense which includes the occurrence and distribution of water in the atmosphere in the form of vapor, on the surface of the earth in the liquid form, or within the geological strata of the earth's crust.

In this broad sense the science of hydrology includes: (1) hydrography, the art of describing the sea, lakes, rivers, and other waters with their phenomena; (2) hydrognosy, the history and description of the waters of the earth; (3) hydro-geology, functions of water in modifying the earth by erosion and deposition; and (4) hydro-meteorology, having to do with water in the atmosphere or its phenomena as rain, clouds, snow, hail, etc. It is closely related to the sciences of meteorology and climatology.

The circulation of water over the earth is and has always been a most important influence affecting the lives of people and also their interests.

Away back in the beginning of time the Creator divided the waters of the earth and caused dry land to appear. This was done during the second day or period of evolution from an unorganized mass of material into an organized earth which was to become the home of man. Thus from the very beginning the proper division of land and water has been necessary for the earth to be inhabitable by man.

In the presence of a favorable distribution of water over a fertile land, man has developed wonderful civilizations only to see them wither and die when the waters went out of control, and the favorable balance destroyed. Civilizations are most secure when a fertile soil exists in the presence of an abundant water supply. A land-water culture is a safe foundation, but if one of these primary elements fails the structure which it supports crumbles.

History shows us that from the most ancient times down to the present, mankind has been conscious of the importance of water to his well being. Nomadic tribes wandered only so far as streams and living springs gave them security. Pastoral peoples sought homes and security along fertile river valleys, and so long as the rivers maintained their flow, prospered and grew in numbers. In some cases when the streams began to fail, artificial irrgiation was resorted to in order to lengthen the growing season; in others the lands were abandoned and new homes sought elsewhere.

These abandoned lands have been called "dead lands," and truly the term is properly applied in many cases. Witness the once rich and fertile valleys of Mesopotamia now a barren desert, or the Sahara or Gobi deserts which were once occupied by a prosperous people. In our own country, particularly the West and Southwest, are also found extensive areas, which are either slowly dying or already dead because of the unbalanced and unstable relation which exists between land and water.

There is no need to present further evidence of the existence of the problem, the question is, "what can be done

about it?" To a certain extent we can answer this question by reciting what has been done.

Man's first approach to the problem was to observe and record the phenomena of the hydrological cycle particularly precipitation, evaporation, and runoff as they occurred. After many years of record keeping it was found that these phenomena had rather definite rules of behavior even though their irregularity left much to be desired. This irregularity taught man the importance of continuous records if we are to have the whole story concerning the phenomena of the hydrological cycle. Single measurements or fragmentary records mean little or nothing. Indeed a short or fragmentary record may be worse than no record at all by leading to unreliable conclusions. Many failures of river control structures can be traced to insufficient stream flow or weather data upon which the capacity of the structure was planned.

Meteorological observations were begun in the United States in 1817 and have gradually expanded since then. Weather forecasts were begun in 1849 by the Smithsonian Institution and continued until the Civil War in 1861, when telegraphic service was disrupted. Comparatively few precipitation records extend back that far, however, and when it comes to stream flow records, there are scarcely any continuous records covering 50 years. Large areas in the United States have no stream gaging stations with a record exceeding 20 years. In the 5 states of the Northwest, Wyoming has only 9 such stations, Montana 13, Idaho 25, Oregon 20, and Washington 25.

Of course we cannot back up and get more long records, the deficiency and need for such is referred to here merely to emphasize their importance and urge that this measuring and recording be expanded and made continuous, thus enhancing the value of the records obtained.

Precipitation and runoff are only two of the several factors in the hydrological cycle. There are other factors equally important although perhaps their effect is not so obvious. Some of them are: (1) rainfall intensity, (2) rate and amount of precipitation at high elevations, (3) absolute humidity at various elevations and at many locations, (4) rate of evaporation under all conditions, (5) amount or volume of evaporation based on evaporation opportunity. (6) transpiration by all plants under all conditions, (7) total amount or volume of transpiration, (8) percolation losses, (9) runoff under all conditions of slope and vegetative cover and precipitation, (10) ground water, occurrence and fluctuation, (11) snowfall on all watersheds reduced to water content, (12) stream flow records on streams not now measured, (13) temperatures at various elevations. All of these factors are interdependent and interrelated, but their relations and influences can be determined only when all the basic data are available and all the laws governing all the various phenomena of the hydrological cycle are fully understood. Perhaps then man might be able to modify or control in a small measure the important balance between land and water which now so seriously limits his existence.

That the activities of man have influenced or changed the land water balance has often been implied. In the early settlement of the west when the prairie was being broken up and grain fields replaced the native sod it was believed by many to have a beneficial effect. Indeed this settlement was actually accompanied by favorable conditions of abundant rainfall. Now a few decades later we find an equally insistent group declaring that the recent and extensive drouth should be

charged to the destruction of the natural vegetative cover by the activities of man, on the ground that with the removal of vegetation through cultivation and destructive grazing, runoff is accelerated so that less moisture is returned to the air through evaporation and transpiration. Which of the two theories is correct? Can both be correct? Perhaps both are wrong. With so many combining factors, however, it is not improbable to expect almost contradictory results.

It seems reasonable to believe that the amount of precipitation which falls depends upon the total amount of moisture contained in the air at a given time, which in turn depends upon the opportunity for water to enter the air either by evaporation from a free water surface or by transpiration from plants. The idea has sometimes occurred that the factor of runoff might be profitably eliminated from the hydrological cycle in some parts of the country. If this were done for example in Washington, Idaho, and Montana the water which was carried inland from the Pacific Ocean and precipitated over Washington could be again picked up and carried on again farther into the interior and so on repeating the precipitation and evaporation process until most or all of it would be returned to the ocean by the air route instead of such a large portion by the destructive and wasteful river route. Should not the capacity of the atmospheric conduit be as great over the Eastern part of the state of Montana as over the western part of the state of Washington? Instead the amount of rainfall received gradually decreases as we get farther inland, the amount received in eastern Montana being less than ⅓ as much as that received in western Washington. See Figure 1 and Table 1. Not only does the amount become less, but it also becomes

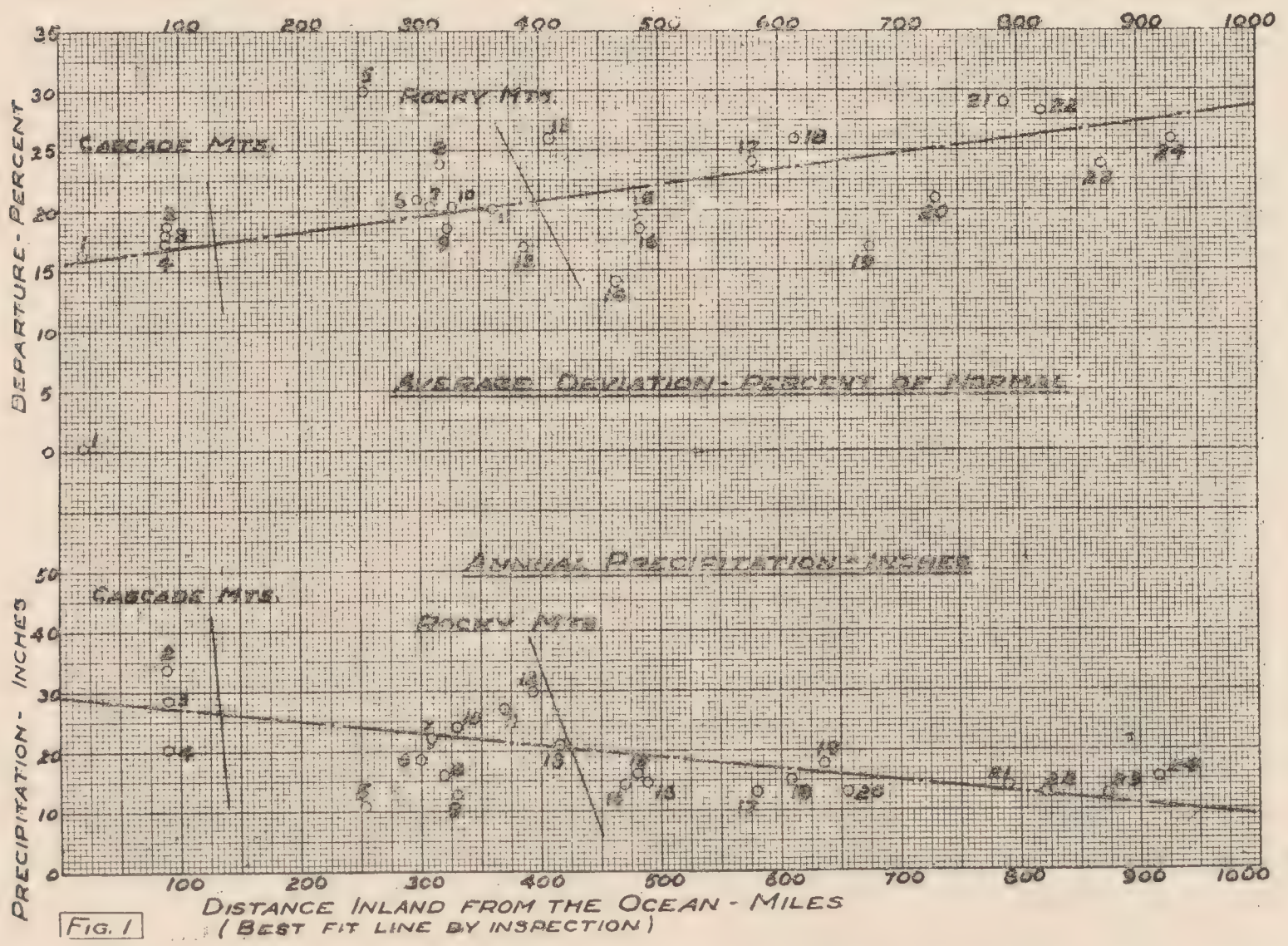

FIGURE .1 Effect of distance inland from the ocean on, (a) average deviation from normal; (b) annual amount of precipitation—inches

more uncertain and irregular, the average departure or deviation increasing from 16% in western Washington to as much as 29% in eastern Montana. See Figure 1b. The values given in Figure 1 and Table 1 represent data taken at representative points which have fairly long and continuous records.

Other facts also support the theory that the extent of evaporation opportunity has a marked effect upon the amount of precipitation received within range of its influence. For example, there are generally two prominent rainy spells during the year, viz., one in the spring while the evaporation opportunity is good, immediately following the melting of the accumulated snows of winter, the other in the fall when the gradual cooling of the air has reduced its moisture holding capacity causing it to drop part of the load accumulated from various sources during the warm summer months. As is well known, the moisture retaining capacity of the air increases very rapidly above 70° so that while the humidity of the air in the hot summer may be too low to cause precipitation, the actual amount of water present in the air may be enough to cause a super saturated condition at a lower temperature.

This is all a very interesting form of rationalizing, but it would be much more interesting if data were available to permit a thorough analysis of the problem.

To solve a problem which depends on the interplay of as many factors as the hydrological cycle, one must cautiously examine all the possibilities before drawing conclusions. The change in a single factor might create for a time an unnaturally high degree of correlation or perhaps apparently destroy all correlation.

For example, a few years ago the writer, out of personal interest, investigated the correlation between the summer rainfall at various points on the

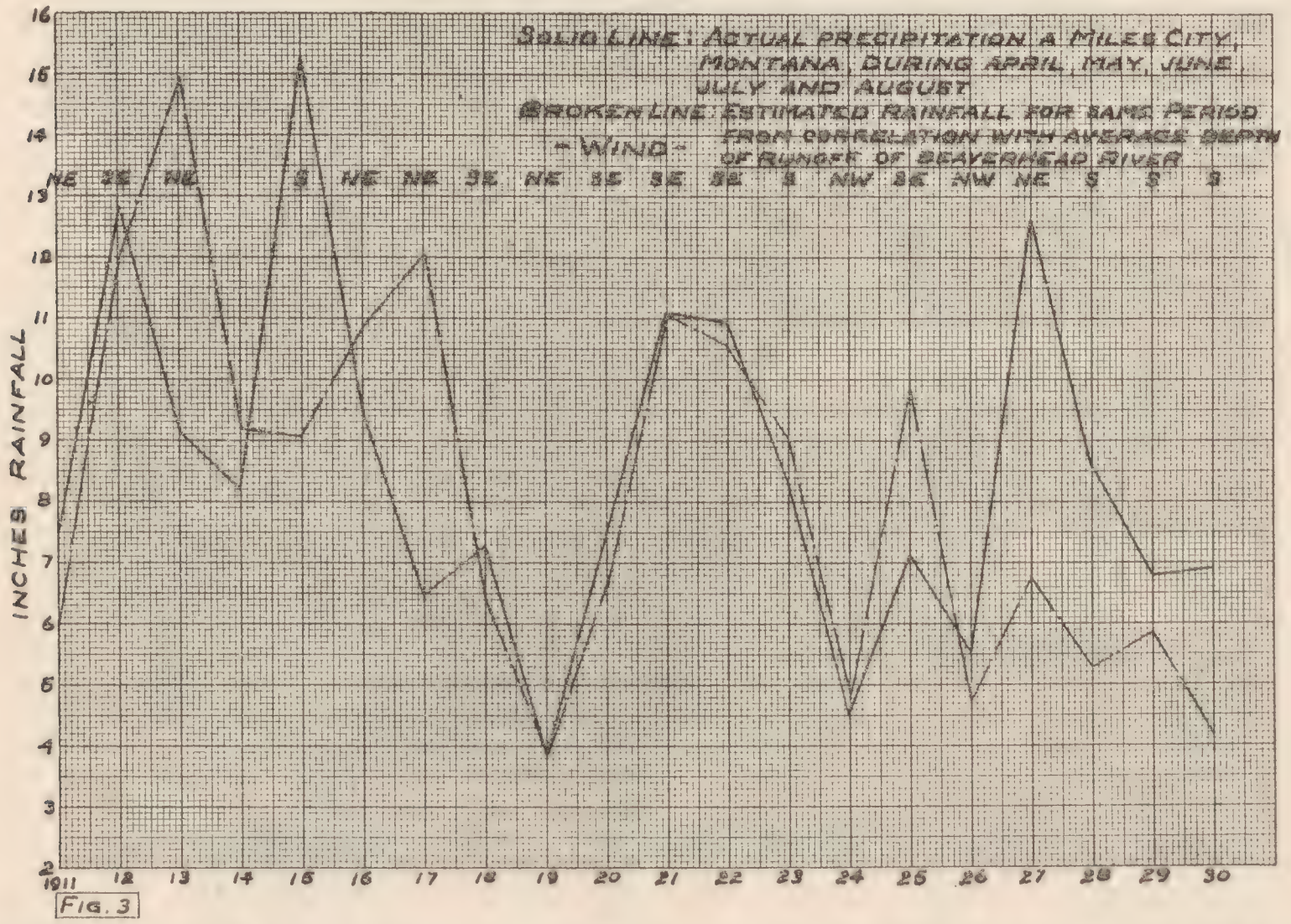
SOLID LINE: ACTUAL PRECIPITATION A MILES CITY, MONTANA DURING APRIL, MAY, JUNE, JULY AND AUGUST
BROKEN LINE: ESTIMATED RAINFALL FOR SAME PERIOD FROM CORRELATION WITH AVERAGE DEPTH OF RUNOFF OF BEAVERHEAD RIVER
- WIND -
RAINFALL
INCHES
1911
FIG. 3

FIGURE 2. Relation between the water content of the snow in Swift Current Basin on May 1 and the amount of rainfall received at Havre and Geraldine, Montana, during May, June, July, and August.

Great Plains with the water content of the snow cover in the Glacier Park Mountains measured at the end of the winter season. It was assumed that the water content of the snow would serve as an index to the evaporation opportunity in that area. When the records of water content of the snow in Swiftcurrent watershed on May 1 and the summer rainfall at Havre were represented graphically, a remarkable resemblance was found to exist (See Figure 2), which seemed to lead to the conclusion that it would be possible to predict in a general way what the summer rainfall situation at Havre and

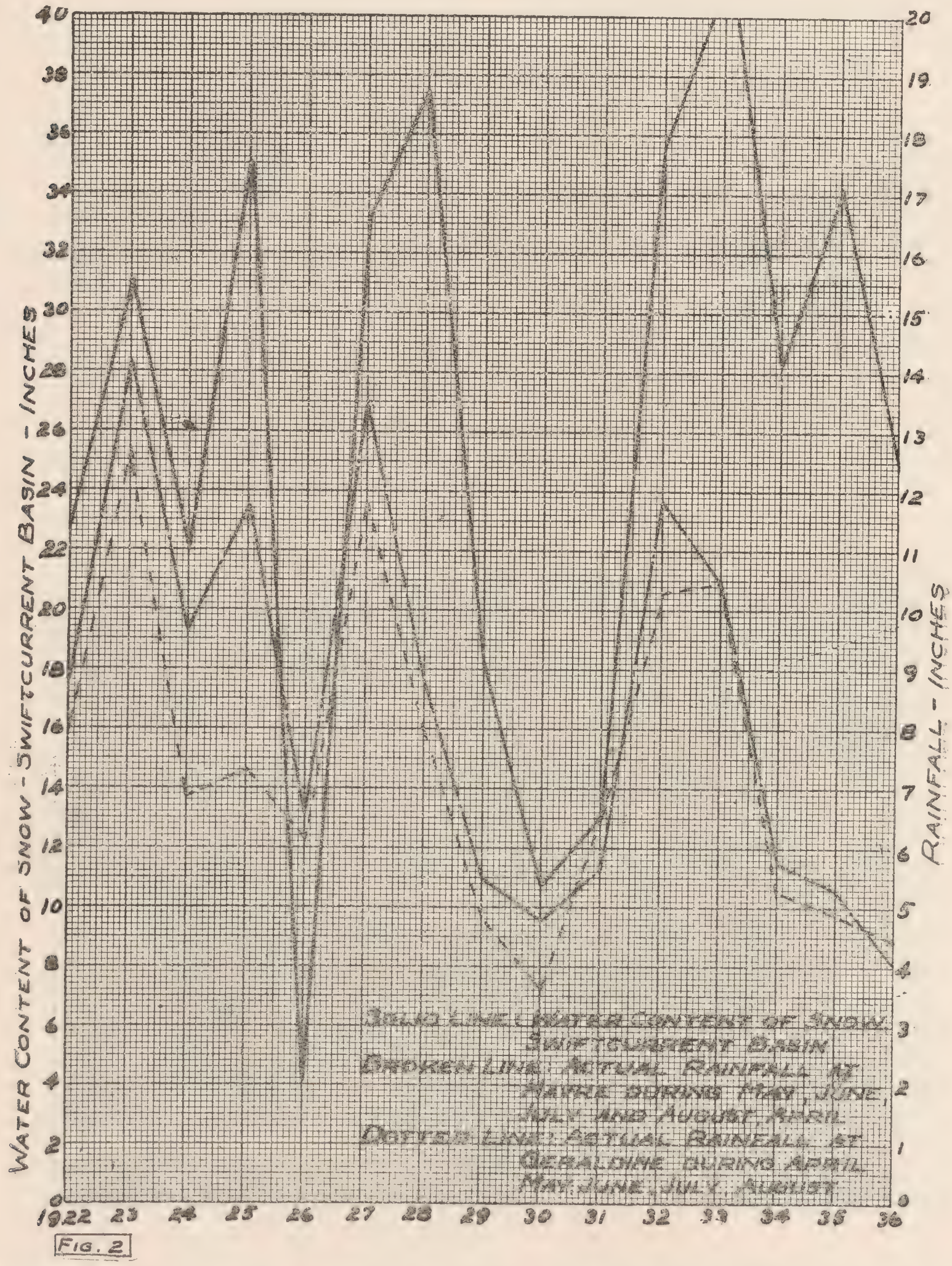
WATER CONTENT OF SNOW - SWIFTCURRENT BASIN - INCHES
RAINFALL - INCHES
SOLID LINE: WATER CONTENT OF SNOW SWIFTCURRENT BASIN
BROKEN LINE: NORMAL RAINFALL AT HAVRE DURING MAY, JUNE, JULY AND AUGUST APRIL
DOTTED LINE: NORMAL RAINFALL AT GLASGOW DURING APRIL MAY, JUNE, JULY, AUGUST
1922 23 24 25 26 27 28 29 30 31 32 33 34 35 36
FIG. 2

FIGURE 3. Summer rainfall at Miles City, Montana, as affected by moisture conditions on the Beaverhead watershed.

Geraldine would be. For example, if the water content of the snow cover in Swift Current Basin on May 1 was above normal, one could, with a good deal of assurance, predict that the rainfall at Havre and Geraldine during the summer months would also be above normal (See Figure 2).

The similarity of the curves appears to be more than mere coincidence, yet with only such few data available for study, a definite conclusion could not be stated. The danger of drawing conclusions from insufficient data is illustrated by another somewhat similar example.

The summer precipitation over a period of 20 years (1910 to 1930), at Miles City, Montana, was compared with the runoff from the Beaverhead Basin, some 450 miles westward during the same period on the assumption that the runoff represented moisture conditions, and therefore the evaporation opportunity on this watershed, nearly 3,000 square miles in extent. A graphical representation of these data (See Figure 3),

Figure 3.

showed a high degree of correlation the first 2 years. The next 5 successive years were very erratic, and the following 7 years were in almost perfect agreement. The remaining 6 years showed some similarity. Now had the period 1913 to 1917 inclusive been studied alone one would have concluded that no correlation existed, while on the other hand, had the period 1918 to 1924 inclusive been selected for study, the conclusion would have been very definitely that a perfect relationship existed. Neither of these conclusions would be justified. Indeed the only conclusion which can be reached is that the complexity of the problem requires a more scientific approach than merely comparing 2 factors out of the many which are involved in the hydrological cycle.

But certainly a more fruitful field for research cannot be found, nor one which promises more valuable results.

The value of national wealth and income which depends directly on the land and water balance amounts to an almost incomprehensible sum. If only a fraction of 1 per cent of this amount were set aside for research and study, much could be hoped for by way of results and if we went a little farther and budgeted for research a percentage which industry allows for experimentation and research the outlook would be still more promising.

The idea may be somewhat visionary, but we will agree that here is a field for research in which, truly, the sky is the limit.

TABLE 1
Average Total Precipitation in Inches and Average Departure from Normal in per cent as affected by distance inland from the Ocean.

	Miles Inland	Annual Precipitation Inches	Average Departure From Normal %
1. Aberdeen, Washington	20	80.8	16
2. Seattle, Washington	93	33.9	17
3. Anacortes, Washington	93	28.8	18
4. Port Townsend, Washington	90	20.4	18
5. Lind, Washington	257	10.6	30
6. Pomeroy, Washington	303	18.2	22
7. Colfax, Washington	312	22.1	21
8. Spokane, Washington	320	16.6	25
9. Lewiston, Idaho	327	13.4	18
10. Moscow, Idaho	330	22.1	20
11. St. Maries, Idaho	367	26.9	20
12. Kellogg, Idaho	393	30.5	17
13. Libby, Montana	414	21.3	27
14. Kalispell, Montana	471	15.2	14
15. St. Ignatius, Montana	481	16.1	20
16. Missoula, Montana	488	15.6	19
17. Helena, Montana	584	13.4	24
18. Great Falls, Montana	615	15.5	27
19. Bozeman, Montana (Agr. College)	637	18.4	17
20. Havre, Montana	685	13.6	22
21. Crow Agency, Montana	796	14.8	29
22. Glasgow, Montana	827	13.2	29
23. Miles City, Montana	877	13.5	24
24. Glendive, Montana	933	15.3	27

In Memorium

F. B. LANEY

Dr. F. B. Laney, head of the Department of Geology at the University of Idaho, died of heart failure, April 24.

Dr. Laney was 63 years of age and had been a member of the faculty at the University of Idaho since 1920. He graduated from Drury College in 1902, later attended the University of Wisconsin and Yale University, earning his Ph D. in 1908 from Yale. Dr. Laney was a former member of the Northwest Scientific Association and had served as chairman of the Geology-Geography section. He was much interested in scientific research, and was a frequent contributor to scientific publications and attendant at scientific meetings.

Dr. Laney had served on the staff of the U. S. G. S., the U. S. Bureau of Mines and several state surveys. His specialty was mineralogical relationships in metalliferous ores.

Surviving are his widow, a son, a sister, and a brother.

Social and Economic Sciences in the Education of a Forester

By SINCLAIR A. WILSON

Senior Forest Economist, Pacific Northwest Forest and Range Experiment Station

Before the Northwest Scientific Association at Spokane, Washington, December 29, 1937

When this formidable subject was assigned to me, my first temptation was to expound upon a number of social and economic studies which would be beneficial to the undergraduate in schools of forestry. I prepared a list of such studies. But when I attempted to fit them in with those now included in the prescribed courses of the forest schools, I found I was up against three very important factors; time within which to pursue these studies, the teaching load, and the aptitude of the student. I have attempted to appraise these factors, without the benefit of the important measuring stick of teaching experience.

The term "social and economic sciences" is very broad and hence rather difficult to define. If I were to accept the term without qualification my remarks would be unusually difficult to follow through to a conclusion. I find it difficult to separate social concepts from economic concepts, because the two are so closely interwoven in true meaning. Thus, Webster defines social science as "the science of all that relates to the social condition, the relations and institutions which are involved in man's existence and his well-being as a member of an organized community; sociology"; and economics as "the science that investigates the conditions and laws affecting the production, distribution, and consumption of wealth, or the material means of satisfying human desires; political economy." For the purposes of this paper I define the whole term "social and economic sciences" as "the sciences of human relations—relations of people with people and of people with things." They involve measurements not only of physical things but also of purposes, the social ends in view.

A well-balanced appraisal of the social ends in view is a task to be performed by one who is proficient in a professional field and in addition is able to work understandingly with and for people. This rule applies to the forester as well as to the doctor, the lawyer, the engineer. It calls for the kind of culture Charles Eliot is said to have described as follows, when speaking on the topic, "The New Definition of the Cultivated Man":

> "In this paper he is not the weak, critical, fastidious creature, vain of a little exclusive information or of an uncommon knack in Latin verse or mathematical logic; he is to be a man of quick perceptions, broad sympathies, and wide affinities, responsive but independent, self-reliant but deferential, loving truth and candor, but also moderation and proportion; courageous but gentle, not finished but perfecting. All authorities agree that true culture is not exclusive, but the very opposite; that it is not to be attained in solitude, but in society; and that the best atmosphere for culture is that of a school, university, academy, or church, where many pursue together the ideals of truth, righteousness, and love."

The science of forestry is definitely identified with social ends, for it has to do with the care of lands and the production and utilization of forest growth for the greatest good of the greatest number in the long run. Whether in generalized or specialized work the forester is confronted by problems dealing not only with the interrelation of things other than human but also with the interrelation of humans, the influences of the things with which he has to deal

upon humans, and the influences of humans upon the things with which he has to deal. Try as he may he can never successfully dodge the cold question, "will it pay?"; and any contemplation of cost involves an economic percept.

The ranger of today is a manager of forests, a superintendent of a staff of men and women, an at least fairly able cost accountant, a key contact man with the logger, the livestock operator, the recreationist, and others who use the forest, and a participant in the whole economy of the locality in which he lives and works, including the farms and communities on the edge of the forest and the welfare of the people living on these farms and in these communities.

As a manager of men the forester must know how to get along with them and how to measure their mental and physical capacities, and this means that he should have a practical knowledge of the rules of human behavior. I tremble for the welfare of young men whose knowledge and skill are appraised by the devious methods of emotion and snap estimate instead of by the method of cool judgment developed by the use of proper measuring sticks and experience.

Scott Turner, recently director of the U. S. Bureau of Mines, has pointed out that "the mining engineer may frequently find himself in charge of a large operation in an isolated place where he is answerable for every feature of the life of a sizable community, and where not the technical problems but the social responsibilities dominate." The logging engineer and the logging superintendent finds himself almost always in this position, and his problems in this direction increase as migrating tendencies of American woods-workers and their families decrease.

As a manager of commercial timberland, it is not sufficient that the forester should know the producing capacity of the land, the composition and growth habits of the stand, the steps he must take in fire protection and logging in order to insure continuous production approaching a sustained yield. He should also know the difference between revolution and evolution and the consequences of each. He should know how to evaluate the effects of shifts in management policy upon both present and future dependent industries, people, and communities. This calls for ground work in the theory and application of economics, and, possibly before that, ground work in political economy so that he may understand why a civilization progresses much slower under a system of radical changes than under a system of economic evolution.

As a manager of grazing lands, a forester should know how to measure the palatability and nutritive value of forage, the carrying capacity of the lands, and to what extent they are being over- or under-grazed. But this is not sufficient if he is to be a good manager. He must know how to measure the dependency of the livestock industry upon the range, the effects of sudden change upon the livestock economy developed, and the complementary steps necessary to compensate the negative effects of progress forward.

The forester is called upon to deal not only with the adaptabilities of individuals and the social problems of a collection of individuals but also with organized groups. In the performance of his duties he may be shifted from one part of the country to another, or if in one place continuously he may have to deal with group movements to and from his local sphere. Knowledge of social problems as well as of methods of investigation is important to competent performance. An understanding of the relation of cultural, biological, and

physical environmental factors to social organization is almost indispensable to success. Readings in anthropology, the history of migratory movements and the effect of occupational opportunities upon changes and movements will broaden his horizons and quicken his perceptions. To deal with labor and other cooperative organizations it would be helpful to be grounded in the elements of sound organization and the principles of collective processing, bargaining, and marketing.

The forester falls short of his possibilities and responsibilities if he cannot add to his knowledge of the sources and convertibility of his raw materials a practical knowledge of how to measure the costs of conversion in relation to the trends in costs of substitutes, and the relative fitness of forest products and their substitutes to answer the requirements of people, to meet their capacity to pay, and to contribute to their happiness. This in turn requires some comprehension of planes and standards of living.

Whether in private or public, in general or special practice, the forester is confronted with problems in government, including taxation. He needs to know how to evaluate forest property in the light of prevailing systems of taxation and how to appraise the tax needs of organized society. It is comparatively simple to devise a tax system that will favor forests, and this may be proper as a temporary expedient when a prevailing system is applied illegally and with persistent unfairness. It is difficult for the individual who has given his whole attention to forestry even to approach a definition of the proper place of forest properties in the existing tax structure and to work intelligently toward economy in government, improvement in tax administration, and reasonable adjustment in the taxation system. Ground work in governmental organization—national, state, and local—and in the principles of taxation is an integral part of the education of a forester.

In these illustrations of the importance of the social and economic sciences in the education of a forester, and in others I might add, I note many similarities in requirements for generalized and specialized work and for the public and the private field. Education in the economic and social sciences is indispensable to success in any field of forestry, no less than education in the biological and engineering sciences. An able silviculturalist or protectionist or operator or economist should know how to move around in the forest and among people.

The dissimilarities in requirements for general and specialized work are found not in the fundamental courses but rather in studies to be undertaken after the fundamentals have been learned, when a man's true preferences have been revealed. The dissimilarities in requirements for work in this region as contrasted with others are likewise found not in fundamentals but rather in subsequent emphasis and are probably best met by practical experience in the field rather than in the school room.

Admittedly, not all the subjects mentioned can be covered in the four-year courses prescribed by forest schools. They could not be covered in that time even if substituted for some of the vocational subjects that could be mastered in actual practice. But I ask this question: which is the more important to the individual and to society, to develop foresters who are thinkers or to grind out forest hands? The need is so to balance the course that the undergraduate student may have a broad understanding of the significance of human as well as plant relations and to supply him with practical methods of measur-

ing them. I note two conflicting general tendencies, which may occur in the same institution: (1) a tendency to substitute some studies in political and general economy for woodworking and blacksmithing; and (2) a tendency to multiply the technological courses by subdivision and thus convert forest education to a superficial process. I cannot subscribe to cramming in a number of different subjects within a single year at the expense of broad readings on a selected few subjects and at the expense of reflective thinking. I do not believe that such a process develops a thinker or prepares a man for the greater schooling that should come in adult life.

What do I believe are the social and economic studies that should be included in the lower-division curriculum-what are the implements for them? I believe that one year's work of three or four credits in each of the following is most desirable: the elements and application of psychology; the elements of sociology, including methods of investigation; the principles of economics; modern governments. To attain progression, it is desirable that psychology and economics be undertaken in the first year of college, and sociology and modern governments in the second. I believe that one year of three or four credits in each of the following implementing subjects is highly desirable: unified mathematics (trigonometry, graphs, algebra, elements of calculus, and analytic geometry; elements of statistics; differential and integral calculus; higher algebra and mathematical theory of statistics; the principles of accounting. It is desirable that unified mathematics and the elements of statistical methods be undertaken in the first year and the principles of accounting in the second. Those who are intellectually qualified should be urged to consider calculus in the second and higher algebra and the mathematical theory of statistics in the third year. These mathematical studies are as important to the biologist and the engineer as to the social scientist. They are all important to the forester who later specializes for the research field. Failure to discuss literature and a reading knowledge of French or German does not mean that I am unmindful of their importance in the education of a forester.

The requirements in upper-division curricula usually include such advanced studies as forest finance, forest economics, forest accounting, cost accounting, and occasionally include business law, transportation, money and banking. The opportunities offered to elect certain subjects in upper-division curricula open the door to advanced studies in the social sciences such as logic, rural sociology, social psychology, public finance, labor problems, transportation, the history of western civilization.

Heretofore my discussion has dealt primarily with the place of the social sciences in the education of every forester, and secondarily with that of a forester who chooses to specialize in forest economics. For reasons stated before I am loath to recommend such specialization at any sacrifice whatever of physics, chemistry, geology, soils, botany, silvics, silviculture, zoology, entomology, pathology, management, surveying, logging, milling, and marketing.

I believe that every forester should be prepared for general practice. However, through elective courses one may begin to prepare for the broad and relatively unexplored field of forest economics and, shall I say, forest sociology. I think actual specialized study should be undertaken after receiving the baccalaureate degree.

The field of forest economics has been broken down[1] into the following divisions:

1. Inventory of the forest resources.
2. Forest-land classification.
3. Forest production.
4. Manufacture of forest products.
5. Marketing and distribution of forest products.
6. Consumption of forest products.
7. Prices of forest products.
8. Forest and forest-industry finance.
9. Public finance in relation to forest enterprises.
10. Public policies in relation to forest enterprises.
11. Social aspects of forest enterprises.
12. Interrelation between forestry and other enterprises.

A mere reading of this list impresses one with the very broad scope of forest economics. Realizing, without further discussion, that forest economics is inextricably a part of forestry and that this field is relatively unexplored, one comes safely to the conclusion that there is opportunity ahead for the forester who specializes in one or more of the social sciences.

For an excellent discussion of education in forest economics and a suggested program of studies leading to the doctor's degree in the field of forest economics I refer you to the report of a special Committee on Social and Economic Research in Agriculture, Social Science Research Council, contained in the February 1935 issue of the Journal of Forestry. The major differences between the course recommended in this report and the one I am suggesting are (1) it includes only four years of undergraduate work, (2) for this reason, it substitutes subjects in economics for certain subjects in the physical sciences, and (3) it omits a study of psychology.

Since we are talking about the social sciences in the education of a forester, in addition to considering subject material we must consider a program of education. Assuming that we are talking about fitting men for a profession, I venture to submit for your consideration my ideal of a program of education. I divide this program into two parts: collegiate and adult. Under collegiate are three subdivisions: undergraduate, leading to a baccalaureate degree; postgraduate, leading to a master's degree; and advanced, leading, for example, toward a doctorate. The undergraduate work should extend over at least four years and preferably five, and should be devoted primarily to generalized forestry. The postgraduate should extend over two years and should be devoted to some specialized field. The advanced studies may require one or more years and, of course, should be further specialized.

Under adult education there are two subdivisions: practical experience in general practice, and practical experience in specialized practice. I believe that from six to eight years of general practice should precede special, in order that a broad and seasoned viewpoint may be developed. I think it a travesty for a man to pose as a specialist until he is quite a bit more worldly than when he left the sheltered halls of academic experience. The first phase of general practice, in either private or public employment, should be a rotating apprenticeship of from one to two years. The second phase should be general practice, preferably under the direction of an experienced forester, for a period of from four to six years. Throughout both phases of this adult course, the forester should read broadly and persistently in the general and special fields, and keep informed of social movements. All of this he owes to himself and to his public. He will be able to follow a good reading program if his percepts have been quickened and his knowledge broadened by a proper undergraduate course.

When this adult course is finished he

may continue in general practice. Should he choose to enter a special field, then I would advise a year or two of intensive work, at home or abroad, preferably with others who are conducting studies in the same specialized field and if possible under an outstanding leader. Following this a subordinate position under a specialist should be sought, and finally either association with a specialist or independent work. During this phase of the adult course I recommend supplemental readings in a broad field, in order to keep abreast of developments in the specialty, in the forestry world in general, and in that greater world, in which all men have their beginnings and endings.

The consummation of this program is fraught with many difficulties, a few of which I will briefly treat as problems. These problems are interrelated.

The first problem is how to change the approach of the student from one of becoming a forest hand to one of becoming a forester. It is not an easy matter to depart from an old way of doing things, for example, the habit of thinking in terms of four years; we are governed to no little extent by tradition. Making departure still more difficult is the pride a college community takes in supplying forest industry with man power even if at the expense of intellectual power. The student's interest in preparing for the immediate job rather than for the long haul, a characteristic of youth, has been accentuated by the demand for vocationally trained men during the depression and the present reconstruction period. This partially explains the perceptibly increased enrollment in vocational courses as compared with static or decreased enrollment in liberal arts. The responsibility for change in direction of interest must rest with the parents, the grade and high school teachers, and the college faculties. I throw down a very definite challenge before the faculties of the forest schools to broaden the horizons of the student, to pass on to him some of the philosophy of service, and to stimulate a possibly latent motive to learn how to think as well as to labor with one's hands.

A second problem, one particularly identified with expanding undergraduate work from a four- to a five-year course, is the financial problem of the average student. I am quite in sympathy with the father and the mother who must scrimp and save and with the student who must find gainful occupation during collegiate years in order to take even four years of work. But the increasing complexities of social existence demand of the leader a greater knowledge of the problems of society, and this necessitates a longer period of undergraduate training. Law, medicine, and other professions have long since recognized this, and within the past quarter century have extended courses of three or four years to courses of six, seven, and eight years. I see very little difference in the lot of forestry students and their parents and the lot of law students and their parents.

A third problem is the unbalanced relation of college appropriations to increased enrollment and the resultant increase in an already excessive teaching load. If legislatures and college administrators could be shown the importance of the forests and forest industries to the regional economy, perhaps suitable provision would be made for instruction and research in forestry on the campus. If they realized the significance of the fact that within this region a large proportion of the acreage is suited chiefly to growing forest crops, that the region's saw timber composes a very large proportion of the national supply, that its protection and multiple-use forest areas are very broad

and important, that its forest industries, employing approximately 150,000 persons, are in need of the services of many foresters, I think that the financial path of forest schools would be made less difficult. The best answer to this problem is an aggressive presentation of the case of forestry on the basis of its proper relation to the needs of society.

A fourth problem lies in the aptitudes of individuals who elect to study forestry. Overlabored and unsound is the oft-repeated argument that, because all men are not cut to the same pattern, courses should be adapted to the broadly varying aptitudes of the great aggregation of eager young men annually knocking at the doors of college. This argument smacks more of emotion than of sound judgment. True, there is a great difference between intelligence and knowledge; but that does not justify sinking the instruction level to the average I. Q. level or preparing one course for the highly intelligent forestry student and a different one for students less highly endowed, and then graduating both groups as professional foresters.

A fifth problem arises from a division in thought in teaching between those who advocate early specialization and those who urge postponing specialization until a broad foundation of knowledge has been laid. I recognize that what is learned but not consistently followed is more quickly forgotten than what is learned and persistently followed; on the other hand, I know that what is forgotten may be picked up later more quickly and effectively than what was not previously learned. I know it is possible to renew partially forgotten knowledge; and I believe it is impossible to transfer knowledge from one field to another. For the instructor in biology or in ecology to teach that his methods of investigation are comparable to those of the sociologist and that the interrelations of plant life are comparable to those of human society would advantageously stimulate student interest, but it would not effect a transfer of knowledge from the one subject to the other. I know it is commonly believed that to stimulate interest in mastering one subject will bring about a continuing stimulus to master other subjects in later life, but I hold that the elements of time and age dull the edges of desire. For example, it is much easier for me at my age to renew and broaden my knowledge of silviculture because of ground work in the elements than it would be for me to start out now on a subject in which I had had no previous ground work, even though closely allied to the former. If I should choose to broaden my field of knowledge I should not now have the patience or the time to dig into the elements, and hence my study would be superficial. The time for broad cultural instruction is in the days of youth. It is frequently argued that the specialist, being well grounded in his line, will later acquire expert knowledge in other fields. But the specialist without broad schooling and experience tends to look upon his subjects more and more through a funnel, cutting off his vision of the outside world. He lifts out cores of knowledge which cannot be fitted into the scheme of life—hence impractical suggestions, much wasted effort, and, permit me to say, revolution instead of evolution.

A sixth problem is that of providing adequately for rotating apprenticeships for the men who are entering general practice, and suitable "clinics" for the general practitioners who would specialize. The United States Forest Service for many years, and in increasing degrees, has provided summer work for students and rotating apprenticeships for graduates, but often has yielded un-

duly to the preferences of the student and graduate. One of the private timber companies of this region has recently initiated a program of moving a graduate around the circle of work and subsequently fitting him into a position if he has made good and the opportunity affords. I believe that private and public forest industries will find it as much to their benefit as to the student's to enlarge the opportunities for this sort of training. As for suitable "clinics" for the general practitioner who would specialize, I recommend that a study be made of the possibilities.

The last problem I choose to discuss in this paper is probably the hardest—it is that of distinguishing between remuneration and the pay check, and between work throughout life and rapid accumulation of property so as to retire from work after a score of years. Remuneration cannot be measured by the yardstick of dollars, because it includes gratification over work well done. Work throughout life, doing that which is before us humbly and to the very best of our ability every day of our existence is more honorable than rank or title. Accumulation for the sake of securing a life of ease, of escaping from exertion and self-denial, is a denial of responsibility to self, to family, and to society. Does not a solution to this problem lie in an understanding of the philosophy of work? Is there not a need for this understanding among all students, all teachers, all foresters? To what extent are our colleges to blame for lack of this understanding? How many institutions of higher learning have not bid for students by placing emphasis on the pay jobs ahead and advertising the salaried positions held by their graduates; have not bid for them without the motive of securing bigger enrollments and hence larger appropriations? To what extent is the idea of training men to think pushed into the background in the competitive scramble for students? I think it should be made very clear to every man that the solution to the problem of getting work after graduation rests not so much in the course a student takes as with the student's intellectual attainment and skill. Let every student know that if he would lead to the best of his ability he must equip himself with both theory and practice; learn the viewpoint of the laborer he would lead by working willingly, humbly, sympathetically, and respectfully at his side; learn how to live with and for people.

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[1] Social Science Research Council. A survey of research in forest economics. Bull. No. 24, September, 1936.

Animal Industry in Relation to Soil Conservation

By THOMAS LOMMASSON

Senior Range Examiner, U. S. Forest Service, Missoula, Montana

Read before the 1937 Meeting of the Northwest Scientific Association, at Spokane, December 29, 1937

In considering the effects of animal industry on soil conservation it is well to keep in mind that nature left to its own devices builds soil and that human coaction disturbs these natural processes and makes it difficult for nature to continue constructive action. In cases where the results of such coaction are extreme, constructive building is stopped and detrimental influences begin the tearing down process. How far this depleting process goes depends upon many factors, some of which are dominant in the struggle for human survival. The use of the products of the soil by animals is not the least of these.

Wherever man has gone, throughout all historical time, he has taken his animals with him. These animals and their work and products are essential to civilized existence. Without them mankind would revert to a much more primitive state. He would no longer have meat, leather, wool, milk, butter and the many other products of animal origin.

Wherever animals have gone the problems of feeding them have also gone. Whenever feed is produced naturally it comes from the soil. Where such feed has been judiciously used the production of the crop has not been materially lessened. Where it has been misused not only has the soil's production decreased or wholly disappeared, from the standpoint of economic use, but the soil itself has been reduced in varying degrees.

Animal industry as a business maintained for profit is what we are primarily concerned with today. Competition in the livestock business results in the crowding of ranges. Crowding of ranges results in depletion of the forage crop. Depletion of the forage crop results in damage to the plant producing top-soil, and continued use under such conditions results in displacement and removal of this essential part of the soil cover.

The history of the use of ranges by livestock, wherever found, follows much the same pattern. With the advent of settlement in a new country the comparatively few settlers turn their livestock on the abundant forage which has accumulated as a result of ideal soil conditions built up during long periods of time and which has been subject to use only by nomadic wild game.

As settlement increased and transportation facilities expanded commercial livestock opportunities improved and numbers were increased to a maximum. Settlement by dry farmers and irrigationists reduced the area of native range lands. The livestock population was forced to use the remaining pasturage. This brought about the major problem of overstocking. Under these circumstances the number of stock operated on a given acreage of range is increased with a corresponding devitalizing effect upon the forage crop. Ranches subdivide and become increasingly smaller. Each of these has a family which must be provided for, children who must be educated and standards of living maintained. In too many cases such small acreages will not support enough stock to provide such a living without injury to the forage crop and to the soil. Under such conditions the operator has but little choice. He must stock heavily in order to gain a

living for his family even though the forage crop will maintain itself for only a few years under such use. When this occurs he usually sells his acreage for what he can obtain and moves, repeating the process elsewhere. Briefly, today, there are too many so-called ranches which have insufficient carrying capacity to provide an economic unit of livestock operation.

These small ranches constitute an economic problem, the eventual solution of which will probably require consolidation into units large enough to support a family and provide reasonable comfort even though the net human population of the range areas may be decreased.

Overinvestment in range lands due to competition or speculation, together with excessive taxes, exert strong influences toward overstocking. Competition for range stimulates increased prices for grazing land. Increased expenditures by Government require higher taxes. Higher wages, higher costs of implements, transportation and materials also increase costs. All of these combine to increase the cost of operation. With excessive investment and overhead an operator's only opportunity to increase income is to increase his number of stock at the expense of the maintenance of his range and soil. Better breeds of livestock and improved methods of operation have lessened this to a degree but the necessity for increased numbers even of the better market types still persists.

High prices for livestock create a desire for larger numbers. Low prices result in many stock being held over until prices go up, both of which increase overstocking on the range.

Overproduction of stored feed is yet another factor. During the normal season the acreage of feed-producing cultivated lands will feed more stock for the winter period than the range lands will support during the spring, summer and fall. As a result the tendency is to endeavor to make the range lands carry as many stock as the cultivated lands will provide winter feed for. Much of the feed-producing land is irrigated hayland, most often native meadows. In many places in the range country the overstocking of range lands can be reduced by utilizing part of the hay meadows for summer grazing, thereby reducing the number of stock on the range.

Still another factor favoring overstocking is the lease or rental system used by absentee landlords, corporations, companies and other owners. The user almost invariably considers that unless he secures every vestige of forage on the leased acres he is not obtaining the full value of his rental. Restriction of the number of stock to be grazed is very rarely a part of the agreement, thereby affording the user the uncontested privilege of overstocking as much as he desires. The unavoidable result after a series of years is serious forage crop reduction, erosion and soil depletion.

Ranges may be stocked with the number which should be grazed and yet be overstocked in part. This is brought about by poor management of stock on the range. It results in congregation of stock around favored grazing and rest areas, water holes and sheltered spots in the case of cattle and horses and at bedgrounds, waterholes and areas convenient to herd in the case of sheep. In both cases parts of the ranges are too closely used, while on other areas feed goes to waste. Its solution lies in more competent administration of range lands.

The constant annual removal of the forage crop over a long period results in reduction of the plant food in the soil and the eventual reduction of the forage crop, which in turn exposes the

top soil to loss. The more closely the forage crop is taken each season the less organic matter reverts to the soil for its enrichment. The forage crop is reduced correspondingly and soil reduction begins increasingly sooner.

The use of virgin acreage by livestock usually follows one of two courses; orderly conservative use, or complete removal of all available forage each season. In the first case the life of a range is indefinite, in the second it is a matter of comparatively few years until the production is seriously curtailed and shortly thereafter removal of soils by erosive action begins. Once the vegetative soil binder is removed, the natural elements of wind and water begin effective work.

A new range may support a certain number of stock when first used but because of such use it will not continue to produce as much as it did before grazing began. This is due largely to the natural adjustment of the plants to the effects of cropping as compared to unhindered growth. This decrease in production causes overstocking in a few years. Its results appear first as a reduction in size due to depletion of vitality. After a period of years this is followed by a decrease in the number of forage plants on the ground. This opening of the stand and the resultant decrease in root competition encourages the introduction of species ordinarily of smaller volume, lesser value and shorter life. These changes almost invariably mean reduced grazing capacity, and exposure of soil.

On a well-managed range enough forage should be left each season to provide protection of the soil against the hazards of seasonal wind movement and of precipitation. Retention of stock on the range after the seasonal grazing period, in order to utilize the residue of the forage crop, is a major factor in increasing damage to the crop and hastening the removal of the topsoil. Removal of an excessive amount of the forage crop removes the cushion which protects the root crown of grasses. The trampling of animals shears the edges of these crowns progressively, thereby reducing the productive plant area and increasing the exposure of bare ground.

The removal of this vegetative cushion also permits the sharp hoofs to contact the bare ground. This tends to pulverize the topsoil and to make removal easy by wind and water. Sheet and wind erosion then begins to make headway. The action of moving soil and water tends to bring about gully erosion first on the steeper slopes. With additional excessive use this extends into the remaining forage stand to destroy the soil and the vegetation. Where the fertile topsoil has been removed and the subsoil exposed, revegetation is much slower even under favorable conditions. Experiments on the Beaverhead National Forest in Montana show that subsoil has revegetated only 43 per cent as fast as the adjoining topsoil, also that the plants produced were transitory in the successional scale and of inferior forage value. Experimental data from the Poker Jim Experimental Pasture on the Custer National Forest show that on a 4 degree slope gully erosion is extending at the average rate of 2 inches a year into the sodded grassland, and 6.5 inches into the sparsely vegetated areas. This extension has occurred largely during unusually dry seasons coincident with which the forage crop has been materially reduced and a minimum of runoff has occurred. It was found also that the trampling and sliding of stock greatly accentuated the rate of widening of the eroded gullies. This damage began when the ranges were overstocked and has lessened materially since numbers have been reduced.

The periodic occurrence of series of comparatively wet and dry years affords still another important influence which has been very conspicuous during recent dry seasons. Where range lands have been progressively reduced by overstocking and are in a relatively depleted condition the occurrence of a severe drouth season serves as the factor which brings about an almost complete breakdown in the plant composition, greatly decreasing the grazing capacity and the chances for rapid revegetation. This condition is outstandingly evident as a result of the drouths of 1931-34 and 36. Where these circumstances prevail an ensuing unusually wet season will greatly augment the rate of erosive action because of the decrease in cover and the disintegration of the topsoil by trampling.

A series of wet seasons also will cause rapid **increase** in the plant population. A series of dry seasons will cause an even more rapid **decrease** in the plant population. This change is graphically indicated by the records of density of vegetation in the Poker Jim Experimental Pasture from 1926 to 1936 inclusive.

In 1926 the plant population covered 16% of the ground at the ground level. In 1930 this had increased to 39% as a result of the wet season of 1927 and the about-average years of 1928 29-30. This represents an increase in cover of 23% in four years. The drouth season 1931 reduced this cover from 39% to 21%, or 18% in one season. The drouth season of 1934 reduced the stand 10% more, and the drouth season of 1936 reduced it an additional 4%, leaving at the beginning of 1937 a cover of 7%. This represents a reduction of 32% of the cover during the three drouth seasons of 1931-34 and 36, or an average of 10.66% each season, as compared to the average increase of 5.75% annually from 1926 to 1930. This represents in a period of three drouth years, which were interspersed with intervening seasons of favorable growing conditions, a 46% faster rate of deterioration than the rate of increase in the favorable period 1926-1930.

These facts indicate that the fluctuation of moisture which is available for plant growth is an important factor in determining the effect of grazing by livestock on range lands and upon resultant effects upon the soil. From a soil conservation standpoint it may be expected that, following seasons of drouth, increased erosive action will occur and that following seasons having sufficient moisture for vigorous plant growth a reduction in soil movement may be anticipated.

The above results are not indicative of the results of moisture only, since this range was stocked with the average number of cattle it would provide feed for each season over a series of years. The use of the range by these stock hastened the reduction induced by the drouth seasons and retarded the increase of plant population during the seasons of moisture adequacy.

It may be said in brief that the adequacy or inadequacy of moisture during the growing season, the conservative or excessive use of the range by livestock and the resultant effect upon conservation of the soil all are directly associated.

The use of range by big game is no different in eventual results than its use by domestic livestock. If conservatively stocked its life is indefinite; if overstocked its life is shortened in direct relation to the rate of overstocking and the adequacy of the moisture supply.

With these circumstances prevailing the question naturally arises: "What can be done to alleviate them to a degree which will allow the retention of ranges in good condition and the build-

ing up of those whose productivity have been impaired, thereby insuring conservation of the soil"? This may be answered in the broadest sense by stating that "control" in its various phases must be induced to bring about these desired results.

It may be stated in conclusion that the relation of overstocking, moisture supply, control, and the conservation of the soil are intimately associated under conditions prevailing on the semi-arid western range.

Irrigated Agriculture in Relation to Soil Conservation

By MARK R. KULP
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Good farm management is as essential for soil conservation on the irrigated farm as it is on the non-irrigated. The continued productivity of farm lands is the object of soil conservation in either case, but each type has problems peculiar to itself. Soil erosion on irrigated lands is not the menace it is in humid sections, but the leaching out of plant foods by excessive irrigation and the resultant alkali and drainage troubles are important in irrigated agriculture.

Soil Erosion on Irrigated Farms

Water.

Any irrigation system is essentially a system of terraces for the distribution and spreading of water by dividing it into small units that will be absorbed by the soil. Irrigation practice that allows erosion is poor practice as it also wastes water which is the principal asset of irrigated agriculture. There is some water erosion under irrigation from careless handling of water, wrong methods of application, poor preparation of land, and depletion of organic matter by continuous cropping to some high-priced crop, but generally the results of erosion on irrigated land are so swift that early precautions must be taken or the land abandoned. The arable land is generally in excess of the available water supply, and the irrigation of steep slopes that involve costly preparation for efficient irrigation is likely to be unprofitable.

Badly eroded or washed fields can be found on most irrigation projects, but the external evidence of damage is covered up in preparing the field for next year's irrigation, and severe damage in consecutive years on the same field is exceptional.

Probably more sediment and suspended material is brought onto irrigated fields in the water supply than is removed by the waste run-off and except on the lower reaches of such streams as the Colorado and the Rio Grande has no detrimental effects. In fact, the sediment-carrying waters of the Nile have maintained the productiveness of the Nile basins for centuries, and the Imperial Valley of California is composed of river silts. The silts of the lower Colorado River have a beneficial effect for a few years when put on sandy soils but are objected to on account of their crusting on older fields and the heavier soils. Fortier and Blaney estimated deposits of $\frac{1}{8}$ inch per year in the Imperial Valley, based on a delivery of three acre-feet per acre with a silt content of .247 per cent by weight.

The average delivery to farms over the irrigated section of the country is about three acre-feet per acre with an average waste run-off of about 12 per cent. With clear water delivered and waste water carrying an amount of silt comparable to the Imperial Valley irrigation water it would take 67 years to

remove one inch of soil from an irrigated field.

There is no doubt that many fields lose top soil at a greater rate than this, as muddy waste water is a common sight. Waste water is commonly picked up and applied to lower fields, and in many cases the waste water is clearer than the water delivered. There is also some transportation of soil within the field, as the larger head of water at the upper end of a furrow has greater velocity than the diminished stream at the lower end, and as the transporting power of water is a function of velocity, some material is carried from the upper end and deposited at the lower.

Land leveling as a part of the preparation of fields for irrigation probably thins out the already thin top soil over about half the area more than a generation of average water erosion.

Irrigated fields bordering natural channels comprise a small part of the irrigated lands and are usually protected against undermining by channel improvement and bank protection.

Soil Erosion on Irrigated Farms Wind.

Wind erosion on irrigated land is seasonal and confined to relatively small areas of particular soil types. Sandy soils can be prevented from blowing by discing in straw and in some cases by methods of irrigation, or by planting wind breaks, or other soils likely to blow when plowed in a dry condition at the season of high winds can be irrigated before plowing. Wind erosion on irrigated fields must be prevented to keep the fields irrigable, and prompt measures are imperative and usually applied.

Other Phases of Erosion.

In early irrigation development, many projects utilized natural drainage channels for part of the delivery and waste water disposal systems, and a certain amount of gullying resulted. As the project grew older, drops and other control works were built to control the velocities in the supply channels as a means of lowering the operating costs of cleaning out diversion works and laterals. The drainage channels were taken care of by the lessened amount of waste water and by diversions of later appropriators.

Canal regulation is usually efficient enough to keep an excess of water from accumulating in any place likely to cause damage, although there are accidental breaks in canal banks from time to time. An irrigation system reverses the natural tendency of water to accumulate and is designed to decentralize the water.

Erosion on the Watershed Supplying Irrigation Water.

Water and wind erosion affect the irrigator by filling his canals and reservoirs with silt, destroying his headworks and canal banks, and by filling his canals with wind-blown drift sand.

Irrigators complained of the earlier run-off due to the burning and cutting of the forests as long ago as 1889. This item was much more important then than it is now since reservoir storage has been provided. The peak run-off and the peak irrigation demand never have been co-incident, and the restoration of forest and range vegetative cover would not provide more than a small part of the regulation afforded by storage reservoirs. However, the restoration of watershed vegetation would be of great value in extending the life of the reservoirs.

Other Forms of Soil Depletion.

Soil erosion on an irrigated farm is of minor importance compared to the greater losses due to the leaching of plant food out of the soil and to drainage and alkali troubles.

Deep Percolation.

Early history of irrigation enterprises

generally shows that the first irrigators had an abundant and often excessive water supply for at least a part of the season. They used this supply lavishly in order to get the largest possible return from the fertility stored in the soil by centuries of desert conditions. They also might overirrigate, hoping that an extra heavy irrigation might carry their crops over a drought caused by a possible break in the newly made canal banks. The results of lavish use of water sometimes do not show up for many years. Every drop of water that percolates through the soil beyond the root zone of the crop plants takes some dissolved minerals and plant food with it, and even the most fertile desert land will finally become deficient in some necessary elements if overirrigated.

Lysimeter experiments and the response of crops on irrigated soils to commercial fertilizers tend to show loss of plant food or loss of availability.

Good farming practice under irrigation does not mean the raising of the highest possible yield per acre but the most profitable yield, and the total of water applied should stop at the point where the cost of applying the next unit of water will be greater than the value of the increased yield. There is some justification for irrigating for the highest possible yield on newly irrigated land because the adverse results will be delayed until the farmer has had a chance to become better established. Development of raw land into irrigated farms is a costly, laborious process, and a certain amount of exploitation of stored-up fertility may hasten development. A settler on an irrigated farm newly reclaimed cannot afford to practice conservation unless the land is all cleared, levelled and ditched, forage crops planted, and buildings and domestic water supply ready for use. Otherwise he must exploit what land he can get ready for the first year's crops. In order to exploit or mine desert soils, abundant water is necessary and the new settler generally has enough water for the whole farm and only a part of the land ready for crops. A certain amount of exploitation may be justified under present and past reclamation practices.

When the whole farm is in crop, conservation should be practiced. On the average irrigated farm only a third of the water diverted from the stream is used consumptively, or in other words, returned to the atmosphere through plant transpiration and surface evaporation, the rest being used, lost, and wasted in canals, laterals, and fields. Canal losses average about 40 per cent of the supply and are mostly seepage losses, evaporation and regulation losses being of minor importance. The field losses are surface waste run-off and deep percolation and when not excessive are considered consistent with good irrigation practice. The surface waste run-off is often recaptured and used on lower fields of the same farm or on lower farms.

Percolation losses from canals and fields accumulate underground and soon overtax the natural underground drainage channels, and we have underground floods which, like surface floods, do not damage the land supplying the excess water. Geological and topographical conditions determine where these underground floods bring the waters to the surface to create seeps, swamps, and alkali lands.

The deep percolating waters lost from canals and fields dissolve large amounts of soluble salts as they pass through the soil, and as they rise near to the surface, capillary movement brings them to the surface where the water is evaporated and the salts deposited and concentrated. When the concentration of these salts becomes detrimental to

plant growth, we call it alkali although many of the salts are necessary plant foods.

As water logging and alkali are confined to only a part of an irrigation project and the rest of the project has contributed to the conditions causing water logging and alkali concentration, the necessary relief through drainage is a community affair. All the losses from a large project may be contracted on a relatively small number of acres, and the best of irrigation practice and land management on those few acres will not save those few acres as a cost within their ability to pay.

In nearly all irrigation projects the underground drainage is inadequate under present conditions of canal construction, irrigation management, and irrigation practice. Drainage is now commonly provided for in the original estimates of irrigation project costs and is recognized as a legitimate community conservation measure.

Soil conservation and water conservation are closely allied problems under irrigation and both have their individual as well as community aspects, but on account of lack of immediate damage the important conservation measures are not generally practiced. Irrigation seasons are extended beyond necessity and in some cases water is run for domestic supply and stock the whole year. Canals go unlined because the losses saved by lining will not return a current profit. Farmers use too much water because they still have poorly prepared fields, use wrong irrigation methods, or do not realize the cost of over-irrigating. Surface conservation practices are general, but soil fertility is exploited more often than it is conserved.

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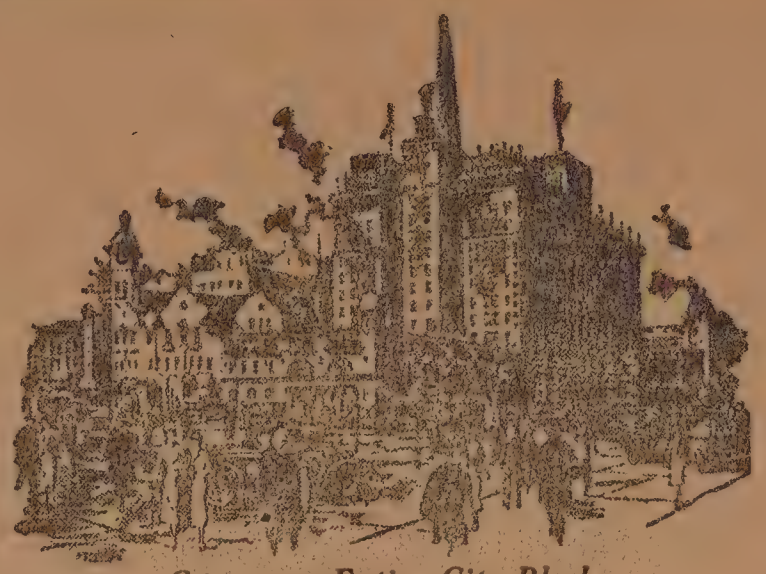

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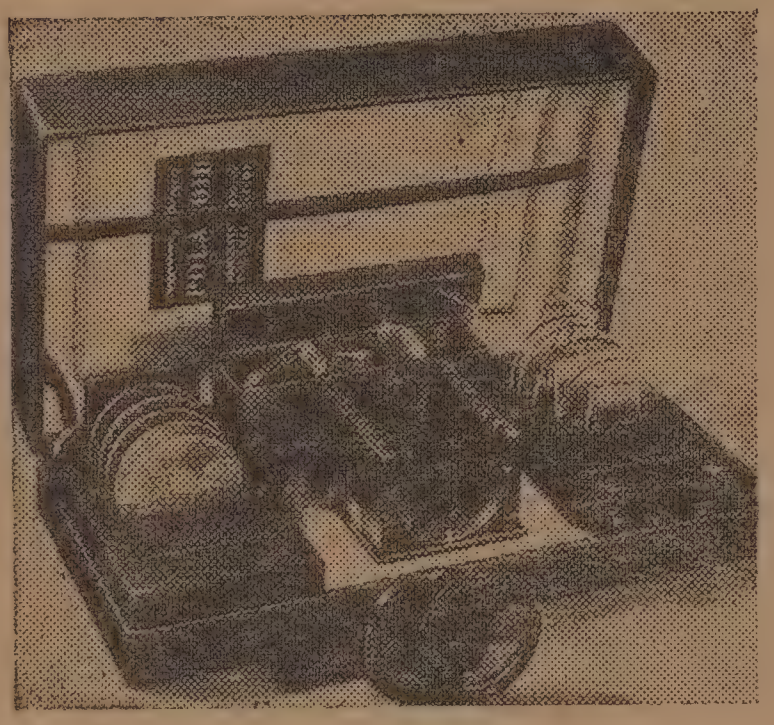

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. . . . . *News Notes* . . . . .

Dr. Alfred Anderson has been advanced to the position of Acting Head of the Department of Geology at the University of Idaho, replacing Professor F. B. Laney, deceased. Dr. Vernon Scheid of the same department has been advanced to the position of Assistant Professor of Geology.

* * *

Professor Richard F. Flint of Yale University, assisted by several students, is studying glacial deposits exposed by construction of the Grand Coulee Dam. From there the work will be extended to neighboring areas. This is the fourth summer spent by Dr. Flint in studying the glacial formations of northeastern Washington. A new conception of the origin of the scablands of eastern Washington was presented by Dr. Flint in the Bulletin Geological Society of America, Vol. 49, pp. 461-524, 1938; and the Journal of Geomorphology, Vol. 1, Number 2, April, 1938.

* * *

Dr. Otis W. Freeman of the College of Education at Cheney will conduct a field party of seventeen people to the Hawaiian Islands during July and August. At the conclusion of this tour, Dr. Freeman will visit the Fiji Islands, New Zealand, and Australia before returning home.

On the week-end of the Fourth of July, a party of sixty-two people went from the College of Education at Cheney for a three-day stay at Lake Chelan. Most of the time was spent near the head of the lake, which afforded opportunity to study the results of glaciation and other interesting phenomenon.

* * *

Mr. J. H. Christ, coordinator of the Soil Service of Moscow, Idaho, has been appointed Regional Chief of the Soil Service with headquarters in Spokane. Mr. Christ replaces W. A. Rockie, the former president of the Northwest Scientific Association, who requested to be relieved of administrative duties so that he might devote all of his time to research problems.

AUG 11 1938

The Denizens of Crater Lake

By J. STANLEY BRODE
Santa Monica Junior College

Crater Lake is the result of a great catastrophe or series of catastrophes in which the top of a mighty mountain was destroyed. In its place remains a vast pit, whose steep sides extend in many places to an elevation of over eight thousand feet and whose bottom lies four thousand feet lower. The water of the lake fills half of this pit, making it one of the deepest North American lakes (1996 feet in 1908).

Because of the location of the lake in this great crater or caldera, the only source of its waters is the snow and rain that falls within the rim or is blown into it. The rim being higher than the surrounding country, the drainage from the outside of the rim is away from it; moreover, the rim being so much higher than the lake (even the lowest point is over six hundred feet above the water level), there exists no visible outlet. There is a certain amount of seepage, indicated by the fact that the seasonal fluctuation of level is greater than the probable loss by evaporation. The actual fluctuation varies from two to nearly five feet and is shown graphically in Figure 1. The actual measurements of lake levels from 1892 to 1908 are few but tend to indicate little variation in the trend from year to year, but from 1910 to 1936 the lake level has dropped fourteen feet. This is important from the standpoint of beach formation and the existence of rooting water plants.

The prevailing winds, which are from the southwest, form a near approach to a beach and pile up some debris on the northeast shore of the lake. Hardly a day passes but has its whitecaps. As a result the shore rocks are washed of most of the sediments and of all but such forms of life as are adapted to rough or stream-like waters. The sudden drop-off of the shore, together with the considerable wave action, prevents the accumulation of the finer sediments and sands near the shore. These sediments come to rest in the cracks and hollows farther off shore. Because of the relative geological newness of the rim and margin little in the way of organic matter finds its way into the lake. The igneous and insoluble nature of the rock, together with the origin of the water directly from rain and snow, make the water of the lake of relative chemical purity.

This chemical purity of the water, its relative freedom from organic matter and fine sediments, make for low turbidity and high transparency. The bottom can be clearly seen at depths of 12 to 22 m. and a Secchi disc disappears at depths between 26 and 29 m. With apparatus borrowed from Dr. Schallenberger of the University of Montana, I endeavored to determine the light penetration. The apparatus used was a Weston Photronic Cell and the current is registered on a portable galvanometer. The results are shown in Figure 2. The penetration at Diamond Lake, a typical mountain lake, and at Upper Klamath Lake, a large but shallow lake, are also shown for purposes of comparison.

The temperature of the surface waters varies from that of melting ice (it has rarely been known to freeze over) to 69 degrees Fahrenheit on a quiet summer day. Below the surface, temperatures drop rapidly to less than 40° F. at 61 m., and drop from 39.3° F. to 38.3° F. from depths of 92 m. to the bottom. The temperature readings made by the Bureau of Fisheries and some of

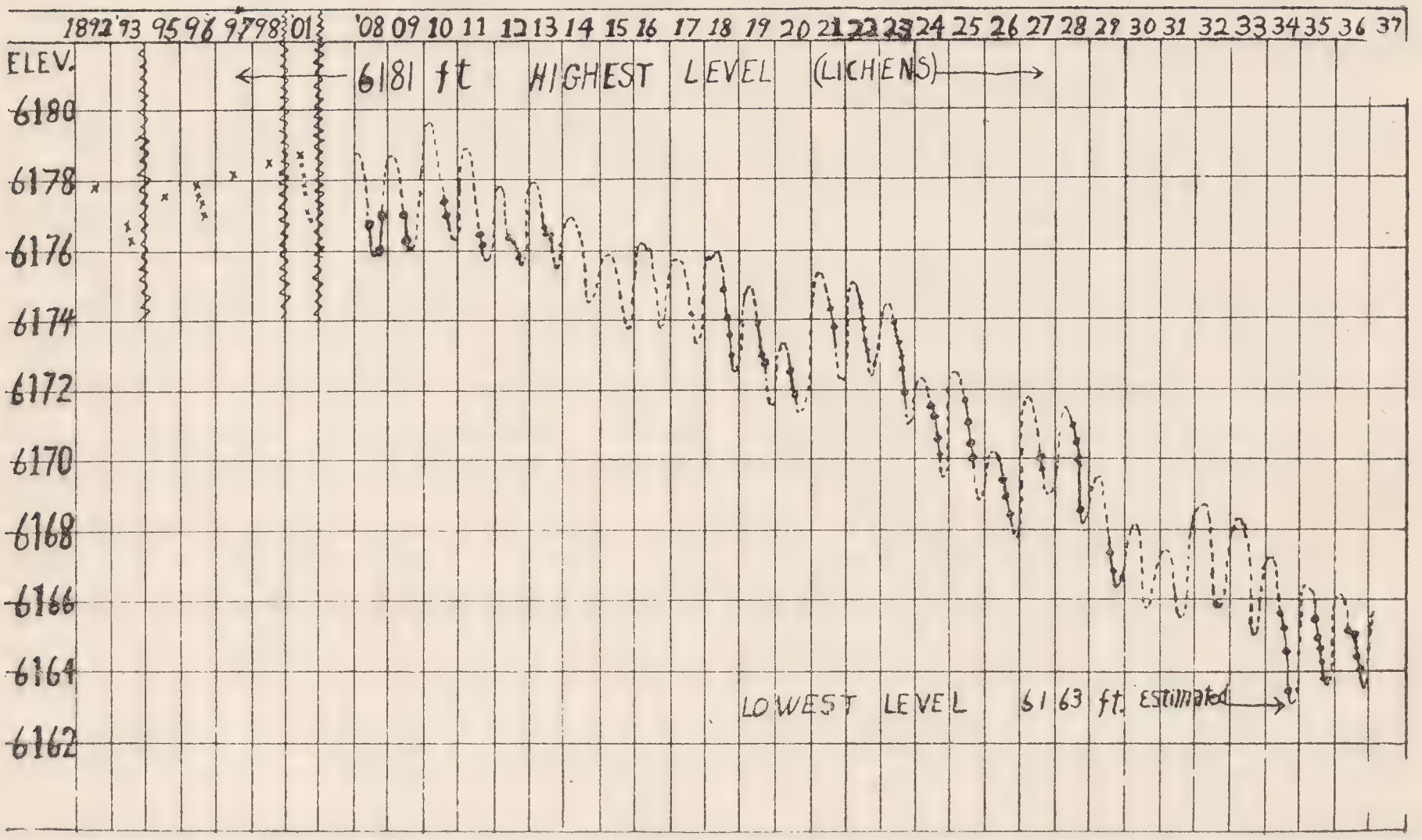

FIGURE 1. Graphic representation of the fluctuations of the water level of Crater Lake, Oregon, from 1892 to 1936 inclusive. The interpolations are based on rainfall date and preceding or succeeding lake gauge readings, and are indicated by the broken line; the dots indicate gauge readings.

Highest gauge reading 6178.585 ft. elev., July 1, 1901.

Lowest gauge reading 6164.3 ft. elev., Sept. 2, 1935.

my own observations are shown in Figure 3.

At first glance this rocky, wave-churned, and fluctuating level marginal habitat seems to offer little to the fauna seeker. It is devoid of the rooted flowering plants such as the lilies, reeds, rushes, and cattails; it is not stifled with the thick soupy algae and plankton growths, as are the Klamath Lakes, or even the near-by Diamond Lake. There is life here, however, but it is more like the life of a running stream (see Figure 4). The apparently bare rocks are covered with a nearly transparent slippery coat that under the microscope reveals minute diatoms encased in gelatinous tubes. These diatoms are so abundant that as the lake level recedes the dry diatomaceous coating remains as a white incrustation on the rocks. After a heavy wind it is not unusual to see suspended, flocculent masses off shore. Anticipating finding a mass of insect eggs, I netted some of these masses only to find them made up of this diatom cover that had been loosened from the shore rocks by the wave action. As the focculent mass disintegrates the relatively insoluble glass houses of the diatoms settle to the bottom with other sediments to form diatomaceous ooze.

The globular, attached masses of *Nostoc* are very plentiful on the rocks and to a much less extent, other blue-green algae particularly *Calothrix, Oscillatoria* and *Chroococcus* occur. These rocks and such logs as those of the landing float also bear the grass-green algae *Ulothrix aequalis* and *Cladophora Kuetzingianum.* While obvious on careful examination, they are not of marked abundance. Of primary importance, however, as a cover of rock surface, especially abundant northwest of

Wizard Island, is an aquatic lichen. These various plant forms are host and probably food to a number of animals. The caddis worm, *Limnophilus,* with its portable house, and another which has an adherent pebble "hut" are plentiful here, as is also the Stonefly, *Alloperia* borealis particularly on the under sides of the rocks. The presence of these types of caddis flies and the stoneflies is strong evidence of the stream-like character of the lake margin. It is interesting to note that, though there are many adult dragonflies over the lake, I have yet to find their nymphs in its waters. The larvae and pupae of the midges, mostly *Chironomus,* are common. To a less extent are found larvae of *Sialis,* and of some of the aquatic beetles.

Planaria are present and, less abundant, are the small leeches and colonies of fresh-water sponge (*Ephydatia robusta?*). In the lake are three snails: (1) a small, flat-coiled, Planorbis-like form, *Menetus opercularis,* occurring in near-surface waters; (2) the most abundant, *Paropholyx effusa,* and (3) the large, thin-shelled *Lymnaea mazamae,* common off shore and to depths of over 15 feet. Three crustaceans are present: (1) near the surface, the cyclops; (2) freely swimming in and out of the rocks, the amphipod, *Hyalella;* and (3) deeper and less active, the crayfish, *Astacus nigrescens* (*Potamobius*). The latter were introduced into the lake in 1915 along the shore of Wizard Island and in its pools. They, with the fish, have survived in the new habitat. An attempt was made to introduce the amphipod *Gammarus.* This form is not found in any catches, nor is it found in the fish stomachs. This is as would naturally be expected, as *Gammarus* prefers warmer, plant-abundant waters. The fish were excellent in 1912 (U. S. Bureau of Fisheries Document 994, 1925) before food introduction experiments, and there is a lack of evidence of any value gained, or to be gained, by food introduction.

A quantitative idea of the density of littoral forms is gained from the census of fifty square inches of the surface of a rock. Here were found: 1 planarian, 5 stonefly nymphs, 1 beetle or neuroptera larva, 3 large caddis cases, 8 small caddis cases, 1 medium sized snail, 2 small snails and a snail egg mass. Where the shore is somewhat protected the habitat is invaded by a small diving beetle, a small waterboatman, and, especially in protected bays or in the below-wave-action zone there are occasional floating masses of pond scum, mostly of *Zygnema,* but with some *Spirogyra.* In this lower littoral "zone" we find the only rooted flowering plant of the lake, the water buttercup, *Ranunculus aquatilis,* rooting and spreading out at depths of five to fifteen feet. An occasional flower stem reaches the surface with a white blossom (I saw three in four summers). In the soil about their base we find a small white clam, *Sphaerium.*

The "amphibious" shore fauna plays its part in the littoral habitat and includes the frogs and toads, the salamanders, *Triturus torosus* (classification in revision) and *Ambystoma macrodactylum,* and the garter snake, *Thamnophis ordinoides.* The water ouzel, the cormorants, and ducks occasionally nest here, but usually only one or two families on the entire lake.

The sublittoral is represented by several forms, including the water moss *Fontinalis,* and with it more of the *Sphaerium* clam. Here an aquatic earthworm is found, and in the mud are other small oligochaetes. The *Fontinalis* apparently covers much of the lake bottom from just below the visibility line to 200 meters or more. I would estimate that it probably covers one third to a fourth of the lake floor. The only place

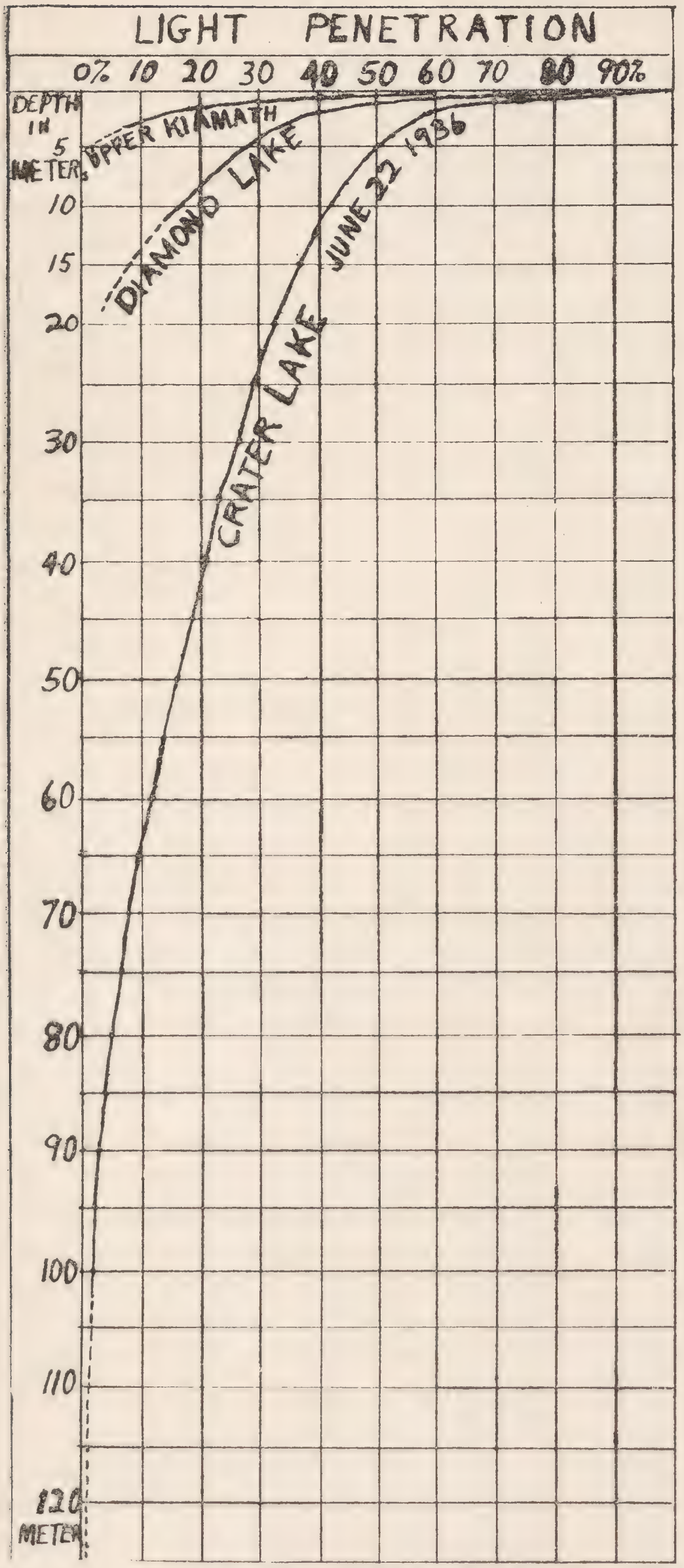

FIGURE 2. Showing light penetration in Crater Lake, Diamond Lake and Upper Klamath Lake, Oregon.

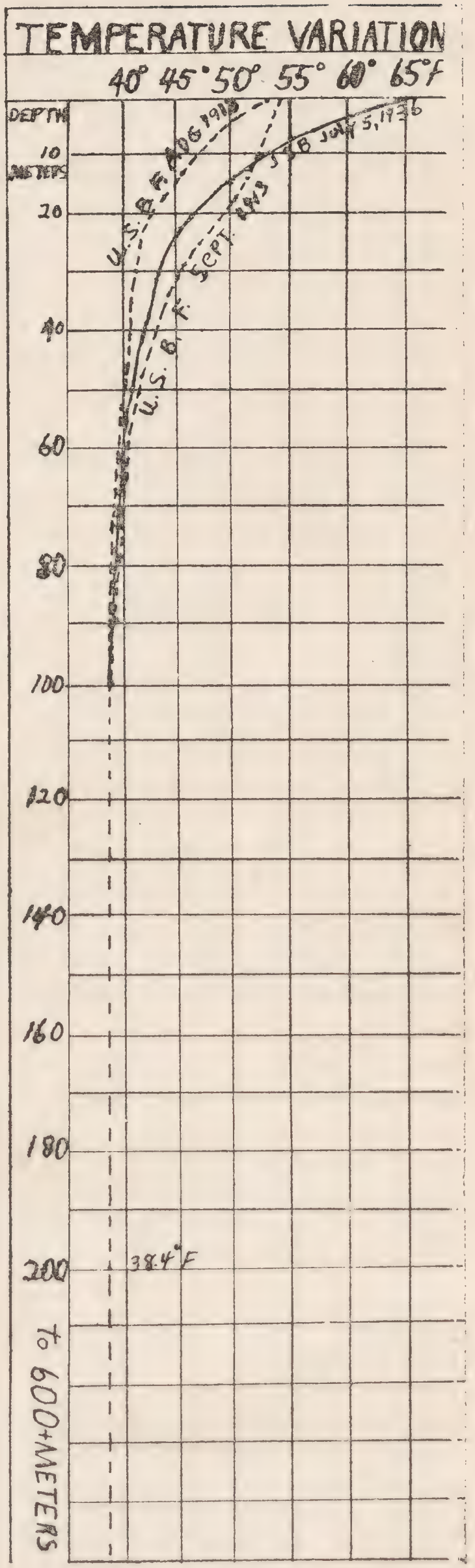

FIGURE 3. Showing the relation of temperature to depth in Crater Lake, based on readings by the author and by U. S. Bureau of Fisheries.

where it comes near the surface is on the "Old Man of the Lake," a derelict log floating on end about the lake. Here it grows and makes a habitat for snails and amphipods.

The plankton is of particular interest because of its limited species and limited distribution. Surface nettings fail to yield results and it is not until the net has been dropped to depths of 15 to 22 m. that one gets a perceptible catch, consisting of practically a pure *Daphnia pulex* "culture." This reaches its greatest density of population between depths of 38 and 53 m. This is of particular interest as they form the largest fish food item, one stomach containing 7500 specimens! The greater depths yield, according to the U. S. Bureau of Fisheries (Document 994, 1925), *Bosmina longispina* at 100 to 150 meters, and the rotifers *Notholca Longispina* and *Anuroea aculeata* at from 30 to 200 meters, the algae *Mougeotia* and the diatom *Asterionella,* the latter from 80 to 300 meters. This plankton distribution is quite in contrast with results on the Upper Klamath Lakes where a surface tow yielded a quart of plankton in a ten foot tow. The *Daphnia* seem to vary in location and since the temperature at their depths is fairly constant we feel that, because of the great light penetration, they go up or down largely with the position of their light optimum, seasonally and perhaps daily.

The neuston (surface forms) holds very few "native" forms. These consist of the waterstriders, *Gerris,* and the springtails, **Collembola**. Stranded terrestial insects and pollen are blown onto the surface and on occasion are quite abundant, the former entering into the food of some of the fish and the latter eventually collecting on the shore rocks.

The nekton in Crater Lake has been introduced to it since 1886, and consists of rainbow trout and silverside salmon. In the lake they feed and are caught from near the surface to depths of over 38 meters. Their food habits are a good indication of those food organisms available in the lake. Figure 4 is an attempt to show the habitat groups diagramatically.

In the summers of 1934, '35, and '36 two hundred and twenty-four stomachs were studied, of which ten were reported as Rainbow trout, *Salmo iridens,* the rest were, for the most part, "Silversides" or silver salmon, *Oncorhyncus kisutch.* The considerable difference noted, both in the amount and in the kind of food consumed during the early part of the summer, in contrast with the food during the late summer caused me to tabulate the results of the analysis separately for each season. Owing to the great disproportion in size between such items of food as a *Daphnia* and a salamander or a fish, it seems wise to compare the percentage composition of the food items volumetrically. The volumes of the various stomach contents were measured in cubic centimeters after the contents had been counted. The percentage of each food item is the ratio of the volume of that item to the total volume of all the items. The tabulation of this data is found in Table I. The total volume of food examined was 2487 cc. or an average for one fish of 11.1 cc. The largest amount of food in one stomach was 95 cc., consisting of 193 caddis larvae and their cases. The greatest number of items contained in one stomach was 7500 *Daphnia.*

Fifty-one per cent of the fish fed on the crustacean, *Daphnia pulex,* which constituted 33.55% of the total fish food. The amphipod, *Hyalella azteca,* made up 6.3% of the food consumed by nearly 40% of the fish. The insects in all stages make up the next important food item, constituting 27% of the food, of which 3% was midge, 18.8% caddis fly (includ-

SUMMARY OF FISH STOMACH ANALYSIS

Food Item	Early Season (June-July) No. fish	Early Season (June-July) No. eaten	Early Season (June-July) Percent total v.	Late Season (Aug.-Sept.) No. fish	Late Season (Aug.-Sept.) No. eaten	Late Season (Aug.-Sept.) Percent total v.	Full Season (June-Sept.) No. fish	Full Season (June-Sept.) No. eaten	Full Season (June-Sept.) Percent total v.
CRUSTACEANS	*94			*75			*169		
Daphnia	75	146,067	47.15	39	20,599	10.75	114	166,666	33.55
Hyalella	38	7,596	6.5	49	4,188	5.97	87	11,784	6.3
Total Crustacean		153,663	53.65		24,787	16.72		178,450	39.85
INSECTS	*58			*53			*111		
Midges	46	7,511	4.845	14	89	.095	60	7,600	3.06
Caddis flies	21	326	10.45	19	1,214	32.4	40	1,540	18.8
Other Aquatics	11	154	.086	5	91	.753	16	245	.756
Land insects	10	83	2.014	17	685	8.113	27	768	4.263
Total Insect		8,074	18.115		2,079	41.361		10,153	26.879
MOLLUSCA, Snails	20	829	13.95	8	79	2.02	28	908	9.44
ANNELIDA, Worms	3	65	1.137	—	—	—	3	65	.212
FLATWORMS	1	.1	.001	—	—	—	1	1	.0008
VERTEBRATE	9			7			16		
Fish	8	8	7.45	7	8	35.35	15	16	17.85
Salamander	1	1	2.23	—	—	—	1	1	1.42
Total Vertebrate		9	9.68		8	35.35		17	18.27
Miscel animal	—	—	2.20	—	—	1.333	—	—	1.85
Bait	7	12	.338	8	21	1.228	15	33	.71
PLANT MATTER	6	21	.885	5	8	1.66	11	29	1.178
INORGANIC (rock)	—	—	—	4	7	.270	4	7	.101
EMPTY STOMACHS	7	—	—	3	—	—	10	—	—
Grand Total	*125	162,686	100.0	*99	27,003	100.0	*224	189,689	100.0

Table 1. Showing the food habits of Crater Lake fish. Data based on the analysis of the stomach contents of two hundred and twenty-four fish secured during the summers of 1934, '35, and '36.
*Excludes duplicates.

ing the sand cases of the larva and pupa stages, which if excluded would reduce their volume about half), and .74% mayfly nymphs. Better than 10,000 insects were consumed by 111 of the 224 fishes, of which the larval, pupal, and adult stages of aquatic forms contributed 9380 specimens or 24% of the fish food. There appeared in the counting 780 specimens of terrestial insects (3% of the fish food). While they make up but a small percent of the food volume, they offer an interesting contrast to the aquatic forms. The latter are represented by 16 to 17 species. There are at least 65 species represented in the terrestial forms counted. Six hundred fifty-five of the 780 are the flying ants which appeared in five of the stomachs during the last week in August and the first week of September. Relatively few of the fish seem to discover the stranded floating insects, only 30 of the 224 fish feeding on them. One stomach contained 35 whole insects and 4 cc. of parts, representing 20 species of insects; another stomach contained 1 blue bottle fly, 1 ichneumon fly, 335 flying ants, 2 grasshoppers, 1 click beetle, 1 long-horned beetle, and 1 irridescent beetle.

The three species or snails were used in early summer by 15.29% of the fish and by 8% in the late season. C. A. Hubbard, in an extensive and painstak-

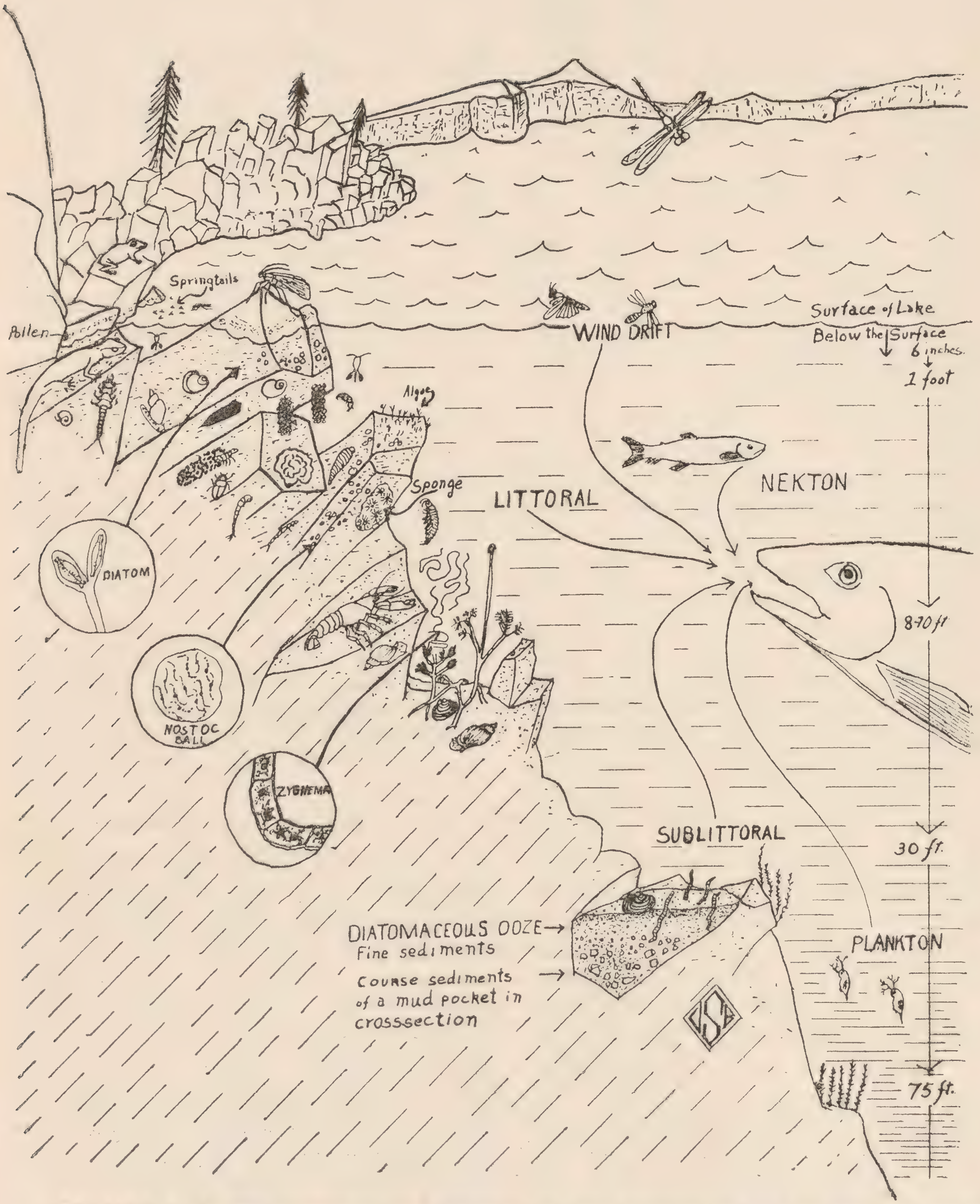

FIGURE 4. A semi-cross-section diagram of the distribution of aquatic life and of fish food associations at Crater Lake, Oregon.

ing unpublished analysis made in 1933, found a *Sphaerium* clam present.

Next in line of food consumption come the vertebrates. A salamander was eaten by one fish and made up 1.42% of the food. Hubbard reported the presence of salamanders in some of the stomachs he examined. In the early season our analysis shows that 65 of the fish had eaten fish, which made up 7.45% of the volume of food, and in the late season 8% of the fish contained fish remains, that constituted 35.35% of the food eaten by the 99 fish. The jump here is interesting in that the planting of fingerlings occurred during the first part of the late season. It is rather doubtful whether the fish were cannibalistic but more likely cleaning up young dead fish that did not stand the transplanting. For some time after the planting dead fingerlings were noted in the waters of the lake.

Annelids were consumed by 6.125% of the fish and made up .42% of the food volume. Of this volume 3 small leeches were found in 2 fishes while 1 stomach contained 62 aquatic earthworms. Only .20% of the food volume was of large earthworms and this was obviously bait.

The small amount of plant food, wads of pond scum and balls of *Nostic* found is possibly due to the fact that the soft-celled material soon became indistinguishable in the digestive process. Rocks, varying from 2 mm. to 20 mm. were found in the late season analysis to .27% of the voulme. Some parasitic round worms were found but were not counted as food content. No attempt was made to determine whether organisms smaller than *Daphnia* were present as we considered their presence largely due to their being food of small animal forms other than fish.

The question of whether the fish were breeding in the lake was a moot one at the time this study was made. For several seasons fish have been caught that had the appearance of having spawned. During the last two seasons small fish were reported repeatedly before the plantings were made, and, while I saw schools of small fish, I do not know whether they were rainbow or silverside, but presume them to be the latter, as it is only since their introduction that the appearance of the small fish has been noted.

It is with pleasure that the author acknowledges the cooperation of the Park Naturalists, D. S. Libby, W. S. Moody, Carl Swartzlow and John E. Doerr, Jr., and the various members of the park staff as well as to Dr. Shallenzburger and others who aided him in this work.

Plant Selection and Breeding in Relation to Soil Conservation

By E. F. GAINES
Cercalist, Washington Agricultural Experiment Station, Pullman, Wash.
(Presented December 28-29, 1937, at the Annual Meeting of the Northwest Scientific Association, Spokane, Washington.)

INTRODUCTION.

Throughout the Ages **Selection** of seed from the most desirable plants has been a powerful tool for increasing the prosperity of the people. It is an artificial acceleration of the Survival of the Fittest for the uses of men,—whether that use be food supply, clothing, shelter, or conserving the soil for generations yet unborn. Breeding increases variation, and, properly guided, brings together the desirable characteristics of different varieties into a new variety which, selected and increased, supplants its inferior parents.

Soil conservation implies not only keeping the soil where it is in spite of wind and water, but also maintaining the fertility of the land while providing food and raiment for man and beast.

Hordes of gullies now remind us;
We should build our lands to stay;
And departing leave behind us,
Fields that have not washed away.
Then when our boys assume the mortgage
On the land that's had our toil,
They'll not have to ask the question,
"Here's the farm, but where's the soil?"

The relation of plants and soils is primarily the surface contact from the conservation standpoint, and each type of soil requires a different group of plants for the best coverage. One group is required for swampy ground, another for hillsides—and a north slope may require different species from a south slope—clay points call for one type of vegetation, acid and alkaline soils require different types of plants, and arid soils and scab lands require plant life adapted to drought and temperature extremes if the greatest coverage is to be obtained.

In selecting the crop for a given field, uses other than soil conserving must be kept in mind as well, or the crop venture may fail because it won't pay the taxes and support the family. It isn t enough to conserve the soil unless revenue to support the present population is furnished. This objective means a change in rotations of part of the land, with soil-depleting crops alternating with soil building crops, and also involves changes in time and methods of tillage, returning the crop residues to the soil, and putting part of the farm down to permanent meadows and pastures. These changes in practice will not come easily. It will take a generation or two of education ,and trial and error, plus Government subsidy, to bring about changes in America comparable to the best European practices. The development, by breeding and selection of plants adapted to the conservation program, may make application possible where failure would result without it. It should hasten the change in any case.

SELECTION FOR PARTICULAR PURPOSES.

Since any soil conservation program, to be accepted, must compromise with soil depleting crops for economic reasons, the improvement of grain crops might be considered in the rotations where they are included. For example, in the most popular rotation in the eastern half of the Palouse Country, wheat and peas, a step in the right direction would be to insist on **spring** wheat and peas, for winter wheat encourages ero-

sion. From 1930 to 1934 rotations showed 93 cents more net returns per acre when spring wheat was used. The spring wheat should be short of straw so that the farmer may disk it in or plow under the residue, rather than burn it. While selecting for short straw, breeding and selection might well be carried on for greater yield, and for resistance to smut and the rusts as insurance against epidemic years like 1937, which took a million bushels or so from the Palouse Country with rust. Similar selection should be made with oats and barley which could be substituted for spring wheat.

Already much progress has been made in selecting wilt-resistant peas. If the pea moth becomes prevalent or the pea weevil gets worse, varieties of chick peas, lentils and soybeans adapted to the pea area but immune to these pests should be ready to take their place.

But this two-year rotation of grain and annual legume is far from an ideal soil conserving rotation. It is, however, better than winter wheat and summer-fallow and has been much more profitable, therefore a step in the right direction. The next step might be to add a grass seeder to the drill and sow sweetclover with the peas. This would make a three-year rotation of peas, sweetclover, and spring grain. The sweetclover could be plowed under in June or perhaps pastured, or a hay crop taken from the more fertile areas, then plowed under later. A few farmers might leave the crop until September and take off a seed crop, plowing still later, since in any event the ground should be left rough and loose until the following spring. After the wheat crop, the field should again be fall-plowed and left rough for peas the following spring.

What variety of sweetclover would be best in such a rotation? That would be determined by experiment. Possibly White Madrid, Yellow Madrid or Willamette, the stem-rot resistant variety, would produce too much top growth for turning under, while the more leafy, fine-stemmed dwarf varieties or Alpha type might be more effective in retarding run-off and produce a better hay and higher priced seed. The ability of the Madrid varieties to grow at low temperatures early in the spring and late in the fall is valuable for erosion control as well as for pasture. By hybridizing these two types, an "Alpha" type that would grow at low temperatures might be selected. It is well to anticipate all the possibilities as 10 to 20 years might be required to develop and increase the desirable type for this particular need.

Alfalfa is probably the most useful perennial legume for the longer rotations in the Palouse Country as a forage and as a soil conserving crop. It merits special research in breeding and selecting for type of growth, winter-hardiness, disease resistance, drought resistance, seed-setting, and yield of hay and pasture as well as ability to get along in various grass mixtures. Since alfalfa is universally grown, the introduction of seed from the four corners of the earth would be a good first step in obtaining variations and possible parent material. To a large extent this has already been done. More study is needed concerning the possible grass mixtures both from the standpoint of the hay crop and from that of the control of undesirable cheat grass as well as erosion control. If the proper grass could be selected to control cheat, it would not only save valuable time in eliminating the spring disking or springtoothing of the alfalfa, but would save some spring washing and produce a cleaner, brighter, clod-free hay. Smooth brome is a promising grass with alfalfa, but much testing needs to be done with different rates and different strains of

the two species. Other grasses such as tall meadow oat, slender wheat, crested wheat, and orchard are well suited for growing with alfalfa under certain conditions.

On almost every farm there are certain draws and flat areas that are too wet for normal cultivation. On these areas timothy, alsike and white clover, the bluegrasses, and redtops do well. All of these species could no doubt be improved by local breeding and selection. The testing plots should be in these wet places where they are to be used if usable results are to be obtained. They should be grown in mixtures as well as in isolated stands for comparative testing, and different types of tolerance must be looked for. Ability to live and grow with their roots in the water in the spring is one essential. Rate of growth and quick recovery when cut or grazed is another. Ability to live a long time or to reseed readily is an advantage for any permanent pasture. Ability to lie dormant during unfavorable weather is another.

Nearly every farm in the Palouse area also has clay points and infertile hilltops that could be profitably seeded down to trees or perennial grasses. For these special species are needed, and a crop improvement program for more adapted strains of each species would pay large dividends. Who will say that there are not strains of black locust and crested wheatgrass better adapted to clay points than others? In establishing a tree covering it has been considered good practice to cultivate the trees the first year or two, but when cultivation becomes impracticable, should wheat be planted for handy game-bird food or should Jim Hill mustard and China lettuce be allowed to come in and take possession? Or would a grass sod be better mixed with sweetclover and alfalfa? Should the trees be pruned or allowed to grow and sprout at will?

These questions force upon us the idea that we are to select and breed plants from a new viewpoint. We must use a different yardstick, if you please, in measuring the value of new plants. Soil conservation is primarily a management problem, but just the right selection of plant species and varieties is a great aid in bringing about the desired end. The Regional Soil Conservation Nursery at Pullman has brought together a large array of plants from far and near for testing and observations. The more promising ones are further tested on widely different locations. Those of proved worth are distributed. At the same time new introductions come in for testing and recombinations of old varieties are made with the plan to develop more useful and more hardy strains than are now available. It is possible that this nursery will be distributing selections 100 years from now that are not in existence at the present time. And that they will be sown or set out by men whose fathers are yet unborn.

The process of breeding and selecting by the performance test takes time, and may be considered a continuous process. The difference between the plant improvement program of the future and the past lies in the change of emphasis from the cereal crops to the forage crops. There have been attempts to hybridize the annual cereals with perennial grasses, but the results have been discouraging so far. Whether a satisfactory grain crop can be grown from perennial roots remains to be proved. If such a crop could be developed even at a considerable loss in yield, it would be very valuable in conserving the soil through reducing cultivation. A larger seeded perennial might be more easily established under adverse conditions. A sod cover, especially on hilly land, is

the best possible. While terraces and gully obstructions are valuable in controlling erosion and in reclaiming eroded land, these devices are not adequate without a vegetative cover.

In annual, biennial, or perennial crops the parts which save the soil are those which are in contact with the surface. For this reason, preference should be given to fine-stemmed, leafy types. Pastures with stoloniferous plants that root at frequent intervals make good coverage. The Kudzu vine of the South with this habit of rooting at the joints is a very popular legume with the soil conservationists. The dangerous quackgrass may have a place in abandoned areas as a soil binder, as it meets many of the requirements of soil conservation. The unpalatable Elymus species should be given consideration around waterholes and where over-grazing is most probable. Sagebrush is better than nothing in over-grazed blow areas.

Every plant has its parasites. Especial care must be exercised in selecting strains that have some resistance to its major fungous, bacterial, or mosiac diseases and insect predators. This point is more important with perennial plants because of the high cost of getting a stand and the infrequency of changing to another crop. Relative ability to choke out noxious weeds needs attention for the reason that it is probably the most inexpensive way to control them and from the standpoint of conserving the soil is much more desirable than using chemicals or clean cultivation.

Weeds are useful on waste places and idle land as soil conservators, but useful plants that would conserve the soil equally well should replace them wherever possible. Public expenditures for planting roadsides to useful grasses, legumes, and shade trees as a means of preserving the road bed, preventing weed seed spreading to farm lands, and increasing the scenic beauty of the country would be a wise use of road funds if properly directed. Permanent plantings can be stimulated to greater weed control by the use of commercial fertilizers if the right combination is applied. Special studies in this field of selection are advisable and justifiable.

A few of the more important species of soil conserving crops that have high pasture and hay values may be listed: bluegrass, bromegrass, wheatgrass, orchard grass, timothy, red top, tall meadow oatgrass, Reed canary grass, fescues, ryegrasses, alfalfa, sweetclover, white Dutch clover, alsike clover, and Indian ricegrass.

Special selection and breeding work on all of these and no doubt many others might yield increased value in soil conservation and economic returns of hay and pasture, if used on soils and in climates to which each is best adapted. Crops are the products of the soil, but it is equally true that soil is the product of the crops that have been grown upon it. Proper management in the sequence of crops, establishing a stand, and utilization of the growth is essential for a permanent agriculture.

The social value of a permanent, self-sustaining agriculture as a national asset should not be overlooked. Instead of mining the soil by the wheat-summerfallow system and after it is worn out and gullied until farm machinery can no longer travel over it, why not diversify and put back into the soil each year as much fertility as has been removed by crops? By careful planning over a long period of time with a proper sequence of crops, combined with wise management and cultivation practices, could not erosion be practically eliminated? Would not these changes encourage home ownership and a decrease in tenant farming? Would it not encourage smaller farms with the best blood remaining on the land? The open

country has long been considered the breeding ground of the nation. Farm families are much larger on the average than city families. Dr. Carver of Harvard is the authority for the statement that three generations of city life brings about complete sterility.

A permanent agriculture would promote rural home life, with pure bred stock, pure seed production, and a continuance of the family farm from generation to generation. A large group of such families would make any nation great, for such land will grow better statesmen as well as better crops and flocks.

Some Forest--Soil Relationships

By LAWRENCE C. WHEETING
Washington Agricultural Experiment Station

A forest soil and the mature forest growing upon it are in a state of dynamic equilibrium. This implies mutual interaction between them, but the forest undoubtedly is the dominant force. A certain type of vegetative cover always tends to build a soil better and better suited for its own growth the longer it occupies a given site. Thus, forests tend to produce soils especially suited for the growth of trees; prairie vegetation tends to produce soils best suited for the growth of cereal plants, and so on. The dominating influence of the vegetative cover is so strong that it definitely determines the character of the soil profile. This fact has led to the most recent conception of soil formation which insists that a soil results solely from the activity of organic life. Weathering processes only produce the parent material from which soils are developed. Weathering is essentially a destructive process. Soil formation is a constructive process. Weathering processes cause a breakdown of minerals, a solubility of basic materials and a leaching away of soluble salts, resulting in the development of secondary minerals of greater stability but of lower nutritive content. Organic life, in contrast, tends to conserve nutrient materials in an organic form from which succeeding vegetation can obtain what it needs and it, in turn, leaves further organic residues. Finally a state of equilibrium is reached where the annual increments of organic matter to the soil just equal the annual decomposition. At what point, in terms of percentage, that this equilibrium is reached is dependent upon at least five factors according to Coile: forest type, stand density, age of stand, soil texture, and soil moisture supply.

Widely different soils may occur in the same territory depending on the kind of vegetative covers that were associated with them. Palouse soils differ from the Helmer soils in this district, not because of differences in parent material, but because the former developed under grass vegetation, and the latter under a forest. It is obvious that the vegetation will also be influenced by the soil which develops under its regime. The soil provides the tree with (1) stability (2) space for a root system (3) moisture (4) nutrients. In carrying out these functions, the soil is changed by the forest so that is can serve best the particular species growing there. Thus, we find certain relationships existing between forest types and soil types. The more severe the environment, the more clear this relationship is. In regions like western Washington where the only unfavorable feature of the environment is the dry summer period, there are only faintly developed relationships, occurring for the most part on sites which intensify the general climatic conditions, particularly the moisture conditions.

From the practical standpoint, as Toumey and Korstian point out, there are marked differences in the use of soils by foresters and by agriculturalists. To the forester, the humus layer of the forest is the keystone of successful forest management.

"Organic matter in the forest serves the same purpose as tillage in agriculture. Agriculturalists maintain soil fertility through the use of crop rotations and the application of fertilizers; foresters by the maintenance of desirable humus conditions. It is as much the task of foresters to develop and maintain a normal forest soil as it is to

MINERAL SUBSTANCES TAKEN ANNUALLY FROM ONE ACRE BY VARIOUS FIELD AND FOREST CROPS

Crop	Ash lbs.	K_2O lbs.	CaO lbs.	MgO lbs.	P_2O_5 lbs.	SO_3 lbs.	SiO_2 lbs.
Field							
Cereals	186	28	14	9	21	4	100
Legumes	173	44	44	11	27	9	9
Potatoes	231	107	36	18	32	14	8
Grass Hay	294	71	44	18	27	11	107
Average 9 crops	235	78	43	17	28	11	37
Forest							
Beech*	194	13	89	15	12	4	56
S. Fir	123	16	75	10	10	4	8
Spruce	138	8	62	8	7	3	45
S. Pine	52	6	24	5	5	2	6
Average	126	11	62	10	8	3	29

*(Wood and leaves)

Noteworthy differences are:

1. More total ash in field crops.
2. More K_2O in field crops.
3. More CaO in forest trees.
4. More P_2O_5 and SO_3 in field crops.

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obtain regeneration and make necessary cleanings and thinnings." The normal forest soil mentioned by Toumey and Korstian is one whose organic layer is in a state of dynamic equilibrium with the environment.

To further orient ourselves with respect to the nutrients required by forest trees as a crop, compared to common field crops, an illustration from a table reported by Schlich is useful.

It must be remembered that time for removal of these nutrients from soils is also a factor in these comparisons. Trees probably are carrying on active growth processes from the time the leaves unfold in the spring until the leaves drop in the fall, while many of the field crops must germinate, grow to maturity, and be harvested in from twelve to sixteen weeks. The forest trees, therefore, take a long time to obtain a notably smaller supply of nutrients from the soil than field crops take to obtain a relatively greater quantity. This may account for the fact that the forest can do quite well on sites where general crop production would fail.

It is only natural for both foresters and soil investigators to interest themselves in the forest litter, or humus layer, since the fertility of the forest and the development of different types of soil are both dependent upon the character of this material. An indication of the interest in this matter is given by the organization of a symposium in the 1937 meetings of the Soil Science Society of America by John T. Auten of the Central States Forest Experiment Station dealing with the different kinds of humus layers developed in different parts of the United States. Monoliths were sent in from all parts of the country and studies made of their characteristics in an endeavor to develop some sort of classification of humus layers which would fit conditions everywhere. It is suggestive of the close relationship between soil types and forest types that the symposium concluded that the soil series names could well be used as descriptive names for the forest humus layers

developed on them. Thus, the names take the form Muskingum duff mull, meaning duff mull produced on the Muskigum soils.

Notwithstanding the obvious difficulty in classification of humus types, which is generally mainly the result of not knowing enough about what we are trying to classify, there is much information of great interest to both soil scientists and to foresters concerning the relation of different types of forest litter and soil formation processes. This relationship is mainly concerned with the products of organic breakdown which enter the soil.

Studies of the decomposition processes of the leaves of different species of trees and bushes have been made at many places. I wish to quote one of the most recent of these studies, made by N. N. Stepanov at Moscow, USSR, and reported at the Second International Congress of Soil Science in 1930. Leaves of oak (Q. pendunsulata), maple (A. platinoides). poplar (P. tremula), mountain ash (Sorbus aucuparia), cherry (Prunus padis), white birch (B. verrucosa), basswood (T. parvifolia), red elder (Sambucus racemosa), spindle tree (Evonymus verrucosa), buckthorn (Rhamnus cathartica), cranberry tree (Viburnum opulus), hazelnut (Corylus avellana), Siberian pea tree (Caragana arborescens), Scotch pine (P. silvertris) and Norway spruce (P. exelsa) were collected and allowed to decay in large lysimeters outdoors for eleven months, meanwhile collecting the rain and snow water which percolated through them. The results are summarized as follows: The first percolation was acid in reaction [maple (4.3)*, spindle tree (5.3), poplar (5.4), Scotch pine (5.4), Norway spruce (5.5), cranberry tree (5.5), oak (5.6), elder (6.1), hazelnut (6.2), mountain ash (6.6), cherry (6.7), caragana (6.9)]. Following percolation waters became more and more alkaline, showing the release of more and more basic materials as decomposition proceeded. At the end of seven months, percolates read: elder (8.3), cranberry tree (7.8), cherry (7.7), buckthorn (7.7), caragana (7.5), spindle tree (7.3), white birch (7.1), Norway spruce (7.0). After eight months, basswood read (7.7), hazelnut (7.4), and mountain ash (7.4). Three kinds of leaves never passed the neutral point—maple (6.56), Scotch pine (6.77), and oak (6.92).

The influence of the different reactions of the percolate on the mineral substances during soil formation can be readily understood from this experiment. Under a process of continued acid leaching such as occurred under maple, pine, and oak, the iron compounds will be soluble and will pass downward in the soil. This will result in a bleaching action of the upper layers of soil and a tendency for the process known as podzolization to occur. On sandy soils, this acid leaching will develop the true podzol soil with an ashy gray subsoil layer and a brown hardpan beneath it.

On the other hand, this process could not take place on the same site if alkaline percolation waters were developed from poplar, mountain ash, cherry, birch, basswood stands. Here the iron would remain in place, no bleaching would occur, and "brown earths" would develop. As Stepanov points out, the influence of the shrub undergrowth in forests may be a profound one in so far as soil development and soil fertility are concerned. He shows that wide differences exist in the amounts as well as in the rapidity with which mineral plant nutrients are liberated by decomposition processes. Since some of these nutrients were obtained from the subsoils, and now become a part of the surface humus layer, the forest brings

(*Refers to pH values.)

about a circulation of basic material within its soil and thereby markedly affects its own site. Just as long as there is enough basic material available to the trees in the subsoils, the soil development will be a favorable one, but if, through wood production, enough basic material is tied up and taken out of circulation and the subsoil supply becomes exhausted, then a new, more acid regime will set in with its resultant decrease in soil fertility and a new succession of species may take place. The artificial planting of a tree species that has a low content of basic material in its leaf litter, on a site formerly occupied by trees with highly basic leaf litter, may also bring about a degradation of a once fertile soil. In eastern United States, instances have been cited of the formation of an insipient podzol soil within a hundred years after a stand of white pine had been planted on an old beech forest soil. This illustrates how intimate the relation is between soil formation and forest types.

The quantity of leaves produced per acre per year by different trees of mature age has been estimated by Ebermayer—beech 3330 lbs. per acre of dry matter, spruce 3000 lbs. per acre of dry matter, and pine 3186 lbs. per acre of dry matter. These quantities are about equivalent to six tons of barnyard manure. The weight of dry matter added to the forest floor annually varies, however, with the quality of the habitat. For the same species, Ebermayer found:

Site quality	**I**	**II**	**III**	**IV**	**V**
Leaves lbs./acre	3047	2213	1462	1149	617

The influence of the depth of litter in forest stands in the Middle West has been shown by Auten. He obtained a good correlation between depth of humus soil and annual growth rates. He found no relationship, however, between available mineral nutrients and growth rates. This is probably a result of the time factor which permits more leisurely absorption by trees.

It is probable that the supply of nitrogen in the forest is the most important single factor in its nutrition. Ebermayer has estimated that an acre of forest trees require from thirty-five to fifty pounds of nitrogen annually. The source of this is difficult to determine. Fallen leaves going into the forest litter contain about 1% nitrogen so that if all of this became soluble during the next season, the trees would be amply supplied, but some insoluble humus containing nitrogen is also formed. Perhaps, however, when the forest soil and the tree growth is in equilibrium, the needs of the trees are met by the annual breakdown of organic matter. This points to the necessity of maintaining the maximum humus layer possible to absorb the rainfall and to avoid nitrogen losses through leaching and runoff.

Certain trees, like the alder, are able to obtain nitrogen from the air by symbiotic nitrogen fixation processes. Root nodules on these trees are often very well developed and older trees have been grown for several years on a nitrogen free nutrient medium. This probably accounts for the ease with which this tree occupies humus-free sites like fresh road cuts, gravel pits, and old railroad grades in western Washington. Alder is also capable of building a rich litter, as is indicated by the preference new settlers show for the so-called alder bottom soils. Investigation of a large number of such bottoms shows that in soil texture, water holding power, and general desirability, such sites may be markedly inferior to soils growing other forest species and the adaptability of alder to poor sites really accounts for its presence there. It is a very poor indicator of good soil. Scotch broom is also

a legume which can successfully grow on poor soils. It is sometimes used in Europe as an under cover to incorporate atmospheric nitrogen into the soil for use by the forest already established.

The natural liberation of available nitrogen from forest humus layers is closely bound up with the ratio between carbon and nitrogen in the material. A group of uncropped cutover and virgin soils in western Washington averaged 21.8 for a C/N ratio, while most cultivated field soils have a ratio of approximately 12. It has been shown that the more narrow the C/N ratio becomes, the more available the nitrogen is. Here then is another illustration of the tendency of a given form of vegetation to produce a soil condition most suitable for itself. Forest trees need a small amount of available nitrogen over a long growing season, a condition which will occur with wide N/C ratios. Field crops need a relatively large amount of nitrogen in a short period of growth, and the organic residues in field soils have a narrow N/C ratio to meet the crop requirements.

In view of these considerations, it is apparent that the forester and the soils man have a common ground upon which much of the success in soil management, either for forests or for field crops, depends. This common denominator of interest is the soil organic matter represented by the forest humus layers.

There are probably a great many other forest-soil relationships that we know nothing about, for they have not yet been encountered and will not be until more attention is given to this inter-relationship between the soil and the forest. To a very great extent, the foresters have not, in this country at least, recognized the fact that the soil is so important in the production of the forest and that the forest determines so definitely the formation processes of the soil.

Granting that this forest-soil relationship is important, what education in soils should a forester have? Should we take a soils man and try to make a forester out of him, or should a forester be trained more adequately in soils? It is likely that the latter is the course to be chosen generally. In addition to the usual introductory courses in soils, it would seem desirable to include as much other soils training as can be conveniently carried. As a minimum requirement in this connection, however, soil classification or pedology and soil fertility should be absolutely required. Enlarged academic training of that rare hybrid—the forest soil man—should profit both sciences.

A Chemurgic Program for the Pacific Northwest

By H. K. BENSON
University of Washington

The application of chemistry to the problems of our daily lives has found expression in a new organized movement known as the Farm Chemurgic Council. It is not a governmental agency nor is it political. It had its origin in the imagination of two famous chemists who unfolded their dream to Henry Ford, who in turn invited a group of farm leaders, industrialists and scientists to be his guests at Dearborn, Michigan, which has now become the center and shrine of the Chemurgic movement in this country. Chemurgy is analogous in its meaning to the word metallurgy. Instead of working with metals, it means working with the annual crops of nature by chemical or scientific methods.

The purpose of the Farm Chemurgic Council is to survey the variety of farm products which through applied science can be transformed into raw materials usable to industry; to define the scientific research problems essential thereto; to stimulate appropriate research both in public and private institutions; to activate American industry to apply the fruits of research; and to encourage the joint cooperation of agriculture, industry and science in promoting this significant development nationally.

It is hoped that this cooperation will result (1) in the gradual absorption of much of the domestic farm surplus by domestic industry; (2) that it will put idle acres to work profitably; (3) that it will increase the purchasing power of the American farmer on a stable and more permanent basis, thereby increasing the demand for manufactured goods, creating new work for idle hands to do, reviving American industry, restoring American labor to productive enterprise and relieving the economic distress of the nation.

Mr. Francis P. Garvan, President of the Chemical Foundation and of the Farm Chemurgic Council, in an article in the Scientific American last December, shows that every depression in our recent history finally terminated because of two things: (1) Expanding markets for old industries; (2) Creation of new industries. He further shows that unemployed acres and men have been absorbed in our national economy in approximately the following ratios: about one-third due to expanding markets for old industries and about two-thirds due to the creation of new industries and the development of new products and new methods.

The natural process of recovery now under way indicates that the expansion of markets for old industries is again occurring in the usual order of things. This should absorb about one-third of our unemployed. But what we are concerned with today is the two-thirds dependent upon new industries for their return to productive enterprise. The new industries that characterized recovery from the depressions in the four decades since 1890 were the products of modern science and invention developed very largely in the fields of mechanical and electrical arts. We might cite one example. In 1920 the first radio broadcasting station was established at Detroit, Michigan. It had one man on its payroll and a few citizens had cheap crystal sets. Now there are 500 commercial broadcasting stations in the United States giving employment to 15,000 technicians and a host of entertainers for the benefit of 25,000,000 vacuum receiving sets in use throughout the country. The catalogue of mechanical and electrical industries that characterize these

four decades is too long to recite at this time.

We are now on the threshold of a chemical revolution which within the next generation will accomplish as much for the well-being of society and for the broadening of opportunity for employment as did the mechanical and electrical revolution of two decades ago. The battlefields of this new revolution are the farm lands of our country. We propose to displace eventually some 250 million tons of raw materials now drawn annually from the mineral kingdom by a like amount of farm products from the vegetable kingdom, all for industrial use in the United States. A century ago the mineral output in this country was one-half the farm output and we had no serious unemployment problems. Today the mineral output is a billion tons and the farm output is one-half billion tons and unemployment threatens our social order. A change in this ratio would require a farm population of about 40 per cent of our total population and would provide employment for every man and woman qualified and willing to work. The Chemurgic movement seeks to make this possible through the objective I have before recited. It is impossible to foresee and to forecast all the ways and means whereby the chemical age will become established. Great numbers of men and women are gathering underneath the standards of the working army. More than 2000 students are enrolled in our chemistry classes at the University. As this generation grows into manhood and womanhood it will be equipped with the implements for moulding a new age of wondrous beauty and service to mankind.

We have already progressed far enough to get a glimpse of the chemical frontiers that soon must be occupied by a happy and busy people. In order that this nation may restore its agriculture and consume its products, several methods of procedure may be followed: (1) The existing farm surplus may be used for industrial commodities; (2) The importation of certain agricultural products may be eliminated, and (3) New crops for industrial use may be introduced.

Some months ago a Chemurgic Conference was held at the University of Florida, Gainesville, Florida. The program laid out for the development in the South over a period of 20 years includes (1) 400 agrol plants utilizing starch and sugar crops for producing a blending constituent adaptable to motor fuel. The way how is determined in the Council's experimental plant at Atchison, Kansas. (2) 200 starch plants using the Southern White Triumph Sweet Potato. The Department of Agriculture's Experiment Station at Laurel, Mississippi, will point the way how. (3) 100 kraft and newsprint mills utilizing the slash pine of the South in accordance with the research of Dr. Herty at Savannah, Georgia. (4) An increase from 85,000 acres to 1,000,000 acres of tung trees in the Gulf States from Texas to Florida.

These four Chemurgic enterprises will require 25 million acres of land, a billion dollars of capital and the labor of 3 million men.

In the Pacific Northwest a different chemurgic program is contemplated. Here the annual crops are of a different nature. We have no corn, cotton or sugar cane, but we have 10 million tons of wood that is wasted or destroyed by fire each year. From the snow that melts under the heat of the sun upon the mountain tops and the water that falls from the highland to the lowland, there may be generated each year 15 million kilowatts of electric energy easily transformed into light, heat, power or into chemical commodities for use in distant parts of our country. We have

millions of acres of idle lands with rich and highly mineralized soils under sunny skies, awaiting only the bringing of water to yield rich harvests of crops. Even now we have agricultural surpluses. There is an annual excess of 20 million bushels of wheat, 10 million boxes of apples grow each year that cannot be marketed and 10 million bushels of potatoes are culls. To found and establish industries that will utilize these idle acres; that will convert these great masses of energy into commodities; that will use every stick of wood that grows in the forest as a raw material for new articles of commerce and that will transform the surpluses of farm, orchard and garden into new and useful products, that is the Chemurgic challenge of the Pacific Northwest.

How may this challenge be met? The answer is not an easy one, but in general it is the same as that which solves every crisis or emergency, viz., leadership. The Chemurgic Conference held in Spokane during March, 1937, provided for a Chemurgic Council of 5 members each from the states of Oregon, Washington, Idaho, and Montana. This council is now in process of formation. Under its direction research projects will be set up that will seek to study the fundamental facts governing the industrial use of our recurring natural resources. In the forested areas of Oregon, Washington and Idaho the application of science, particularly chemistry to wood, is of prime importance. The logging and sawmilling industries by their mechanical methods use only one-third of the tree as it stands in the forest. The pulp industry by its chemical method utilizes only the cellulose of wood—less than one-half of its raw material. The residue consists of lignin and wood sugars, now washed into the rivers and sea as a waste product. Chemical research must be undertaken in an organized way and with trained personnel before the lignin waste can be salvaged and turned into the channels of trade and industry.

The second great industrial waste is that of the energy of falling bodies of water. It is foreign to the ordinary way of thinking to regard hydro electric power as a recurring crop or natural resource. But it is just as much so as the annual growth of wood or any farm crop. The energy of the sun light, the water from the ocean in the form of vapor which condenses to rain or snow on the higher elevations until the summer season causes it to melt and fall from the highland to the lowland.

The conversion of electrical energy into chemical energy or chemical commodities is not a mystery and is not any more difficult than its conversion into any other form of energy. From water, air and electricity nitric acid can be made. Synthetic ammonia and phosphoric acid utilize electricity as does also calcium carbide and the light metals industries. At Trail, British Columbia, the State College at Pullman, at Kellogg, Idaho, and Anaconda, Montana, are groups of workers now engaged in research and in actual production of commodities from energy that may be derived from one of our greatest resources.

Our farm surpluses of wheat, apples, potatoes are capable of diversion into industrial channels. California now utilizes 30 per cent of its citrus fruits for pectin, fruit juices, wines, flavoring oils, citric acid, stock feeds and the like and is doing it at a profit. It is gratifying that the University of Idaho has taken leadership in the conversion of the starches in cull potatoes and other carbohydrate crops into alcohol that will ultimately find its way as a blending constituent into gasoline to make it more suitable for use as an automobile fuel.

The introduction of new crops into

this region is not without the range of possibility. At the present time nearly all of the cigarette paper is made from old rags in France. The owners of these plants are much interested in similar and better papers that have been made from Oregon flax. A research project in Oregon would be timely in laying the foundation of a cigarette paper industry in the Northwest.

These and other tasks must be assumed by the people of this region. We must seek more and more knowledge concerning these things and uncover more and more facts that lie at the base of chemical industries. The only way is the way of science and that is the chemurgic way: the mobilization of science through research in behalf of agriculture and industry.

May I repeat once more the four major research projects upon which the chemurgic progress of this region depends: (1) a pure science research of lignin, the greatest wood waste in the world, together with technologic researches looking to the 100 per cent utilization of wood by chemical processes; (2) electrochemical researches in appropriate locations to convert electrical energy into chemical commodities from air, water and minerals; (3) technical and economic researches to convert agricultural wastes into products marketable at longer ranges of time and space; (4) chemical investigations of flax products to replace imports of cigarette paper, linseed oil and oil cake.

The Proceedings of the Chemurgic Conference in Spokane last March are now available for distribution. In them an even larger program is unfolded for this region.

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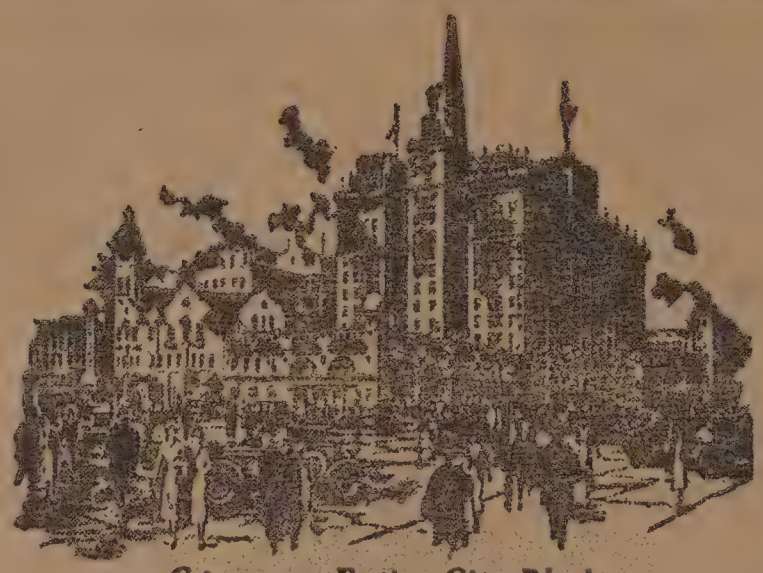

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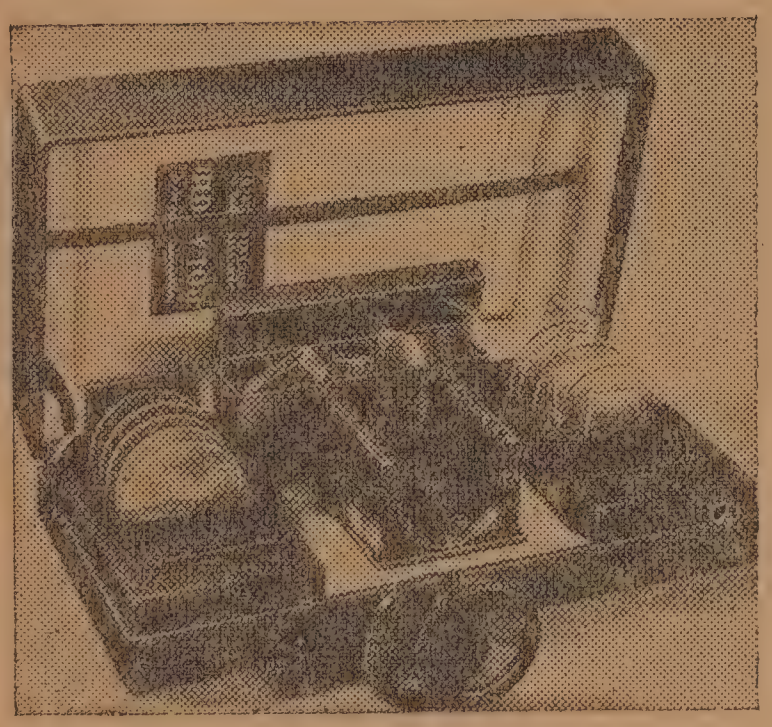

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Association Meeting, December 28 and 29

The Fifteenth annual meeting of the Northwest Scientific Association will be held Wednesday and Thursday, December 28 and 29, 1938, in the Davenport Hotel, Spokane, Washington. Members should note the date is one day later than originally announced. It is hoped that a record number of members and their friends will be present for the meetings. Plan to come and bring someone else with you.

The program of general session speakers is not complete at the time of editing this number of Northwest Science; however, several features have been definitely assigned. Dr. C. C. Todd, Dean of the College of Science and Arts at the State College of Washington, will give the retiring President's address, taking for his title, "The First Northwest Scientists." In his address, Dr. Todd will recall the scientific contributions of the Lewis and Clark expedition and the journeys of David Thompson.

Mr. W. A. Rockie, an ex-President of the Association, will be presented at one general session or at the Sigma Xi breakfast, Thursday morning. He will speak on Alaskan agriculture.

The Associated Engineers-Northwest Scientific Association joint luncheon will be held Wednesday, December 28. The motion picture film produced by the Washington Water Power company on "Power Development in the Pacific Northwest" will probably be the program feature.

Dr. Phillips of the staff of the Rocky Mountain Biological Station at Hamilton, Montana, will speak on Rocky Mountain fever research. An exhibit from the station will also be on display.

Negotiations are under way to secure M. L. Wilson, Assistant Secretary of Agriculture, as a general speaker.

Aside from the eight regular section meetings, the Section of Hydrology of the American Geophysical Union and a Snow Survey Conference will hold meetings under the auspices of the Northwest Scientific Association.

W. B. MERRIAM, Secretary.

DEC 19 1938

Soil-Borne Cereal Diseases in Coastal Oregon[1]

RODERICK SPRAGUE
Associate Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture

INTRODUCTION

The profitable production of hay oats in Oregon counties bordering the Pacific Ocean is hindered by crown rust (*Puccinia coronata Corda*), root rot, and foot rot diseases. These combined with frequently unfavorable climatic and soil conditions materially reduce or sometimes destroy the oat crop in this section (3,8).

THE REGION

The coastal area of Oregon is a narrow strip between the timber covered coast range of Oregon and the ocean. The cultivated land is limited to clearings along narrow river valley bottoms ("shoe string" valleys), a few islands, deltas, and, to a less extent, headlands and uplands. The associated area at the mouth of and along the Columbia River forms a connecting link with the interior Willamette Valley. Most of the soil of the coastal strip is very acid (pH 4.8 – 6+) and the soil types range from the residual "red hill" lands through a series of colluvial sandstone, shale and basaltic origin soils to muck. The red soils, as shown by Stephenson and Powers (11), respond to liming and are usually deficient in nitrogen and phosphorus (2, 11).

The climate is featured by mild, moist weather from October to April or May and relatively rainless but frequently cool and foggy summers. At Astoria, fog is very common in late summer and crown rust is prevalent on oats and a number of grasses.

Production of cereals in the coast region is largely limited to hay oats, although a small acreage of wheat is grown. The seed oats are usually purchased at available points (i. e., Corvallis, Astoria, Eugene) and the entire crop cut for hay on the majority of the farms. The farms are usually small and often too isolated for the practical purchase of lime or even commercial fertilizers. Since the soil-borne foot rot troubles are one of the limiting factors in the successful production of grain in this region, studies of them were made from 1930 to date. The present notes deal mainly with studies made on fall-sown grains.

STUDIES CONDUCTED

An experimental plot was maintained in the Alsea River Valley, Lincoln County, Oregon, from 1930 to 1937. Plots were maintained at the John Jacob Astor Experiment Station at Astoria from 1936 to 1938 in conjunction with cooperative work between H. H. Howell, the Oregon Agricultural Experiment Station and the oat project of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

The soil at the Alsea Valley plot was colluvial, originating from sandstone and shale. The soil, which classes near Sites clay, is easily tilled even after lying exposed to heavy winter rains. It has a wilting point of 16 per cent, saturation point of 50 per cent and is very acid (pH 4.8 – 5.3). A rain gauge and hygro-thermograph were maintained at the site of the Alsea Valley plots. The humidity, except in midsummer, is high, the air being aptly termed "muggy". The precipitation from September 1933 to August 1934 was 74.9 inches, from September 1934 to August 1935, 87.7 inches, and from September 1935 to June 1936, 78.0 inches. The monthly precipitation ranged from 28.7 inches for December 1934 to a fraction of an inch for some of the summer months,

indicating the extremely variable seasonal conditions of the region.

Symptomatology of the Soil-Borne Cereal Diseases in the Alsea Valley Plots.

The combination of symptoms induced by unfavorable growing conditions due to soil, weather, and parasitic fungi produced an extremely complicated series of pathological conditions in the various hosts. The symptoms will be discussed by hosts.

A. **Barley**. All varieties of fall-sown winter barleys failed to thrive in the very acid soil. They emerged with about a 50 per cent stand, failed to produce any appreciable root system, and showed all stages of chlorosis including plants with white leaves. On the advent of rains, various root and leaf rotting fungi destroyed most of the survivors. A few plants lived until spring. They developed either the light tan eye spot foot rot lesions of *Rhizoctonia* (5, 6) or the roots and culms were blackened by mycelia of *Helminthosporium sativum* P. K. and B. or sometimes *Ophiobolus graminis* Sac. (4).

Spring-sown barley survived scarcely better than fall sown. It was particularley prey to *Rhizoctonia* and *Fusarium culmorum* (W. Smith) Sacc.

As judged from these statements barley is scarcely ever grown in the coast region, although occasionally spring barley is found in soils less acid than those in the Alsea plots.

B. **Oats.** In the fall, winter oats emerged in satisfactory stands and showed little indication of chlorosis due to hyper soil acidity. During the winter months the root systems of oats in the Alsea plots were weaker than in winter oats grown in the Willamette Valley. A condition termed brittle root was common, particularly in the varieties of the red oat group (*Avena byzantina*). The roots were shortened thickened, brittle, and root hairs few and often distorted. The leaves of the varieties of the red oat group, and to some extent those of the Oregon Gray (Winter Turf) variety (*A. sativa*) showed a large amount of "red leaf" condition. The symptom is attributed (7) to a number of causes, those pertaining to the Alsea Valley being:

1. Excessive soil moisture and resulting decrease in oxygen supply to the roots coupled with the increased soil acidity and depleted available nitrogen in late winter;

2. Soil-borne root rots, particularly *Fusarium culmorum*:

3. Leaf fungi, including *Pseudodiscosae avenae* Sprague and Johnson, which causes the red leather leaf disease. In addition to this fungus, which appears to be increasing in severity every year, *Helminthosporium avenae* Eidam was widespread on oats, particularly on the semi-winter-hardy varieties of red oats: Red Algerian, Kanota, and Red Rustproof. *Septoria tritici* Rob. (10) also was abundant on winter oats in the plot.

In the spring some of the varieties of winter oats made a quick recovery, others failed to respond to the warm weather, did not stool and eventually were destroyed by root rots. All varieties showed attacks by *Fusarium culmorum*. It reduced the root system and caused pale brown lesions on the roots and culm base. Spores were produced abundantly on the culm bases.

A large number of oats in the plots developed blackened culm bases due to the formation of stromatic tissue of *Helminthosporium* spp. The condition was found in late season (May-June) with traces apparent earlier.

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[1] Cooperative investigations by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon Agricultural Experiment Station. Published as Technical paper No. 298 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Botany.

It was believed to be of minor importance and parasitic only because the plants were growing in infertile, acid soil.

Perithecia of *Ophiobolis graminis* were found on oats in the Alsea plot, but the plants were usually parasitized by *Helminthosporium* and *Fusarium* as well, and the symptoms therefore were frequently confused.

Symptomatology of the *Rhizoctonia* disease has been discussed previously (5, 6). The elliptical light colored eyespot lesion on sheath and culm was distinct from other foot rot symptoms.

C. **Wheat and Spelts.** Most of the wheats, either fall or winter sown, are only slightly better adapted to the acid soil of the Alsea Valley than barley. Failure to emerge, chlorosis, stunting, brittle root, and the complex of final root rot symptoms are characteristic of the symptoms displayed by most varieties. Little Club, for example, never attained a height of more than 8 inches and the minute heads contained from one to six shriveled kernels.

Certain soft red winter wheats, particularly Fulhio, resisted the acid soil conditions and yielded nearly as well as Oregon Gray Winter oats. However, they were susceptible to the *Rhizoctonia* foot rot and showed take-all, *Helminthosporium*, and *Fusarium* disease symptoms.

The winter spelts were resistant to the acid soil complex but they suffered mechanical injury by soil washing as the plants did not form satisfactory leaf rosettes during the winter. The same general symptoms of root rot and foot rot shown by Fulhio wheat were shown by the spelts.

The Associated Fungi.

The following fungi were either seen in fresh material or isolated from it and maintained in pure culture.

Fungus	Season	Prevalence	Isolated + or —	From	Hosts
Absidia sp.	Winter	Common	+	Root	Oats, Wheat, Barley, Spelt
Mucor sp.	Winter	Common	+	Root	Oats, Wheat Spelt
Fusarium culmorum	Winter, Spring	Common	+	Root and Culm Base	Oats, Wheat, Barley, Spelt
Fusarium spp. (roseum group)	Winter, Spring	Common	+	Root and Culm Base	Oats, Wheat, Barley, Spelt
Helminthosporium sativum	Spring	Common	+	Culm Base	Oats, Wheat, Barley, Spelt
Helminthosporium avenae	Late Spring	Moderate	+	Culm Base and Leaf	Oats
Ramularia sp.	Winter	Occasional	+	Root	Oats, Wheat
Rhizoctonia sp. or spp.	Late Spring	Common	+	Culm Base	Oats, Wheat, Barley, Spelt
Ophiobolus graminis	Late Spring	Occasional	—	Culm Base	Oats, Wheat, Barley, Spelt
(?) *Aphanomyces* sp.	Midwinter	Moderate	—	Roots	Oats

During the winter months non-septate fungi and *Fusarium* spp. were most frequently isolated from the roots of cereals in the Alsea Valley. The foot rot fungi developed in the spring except during the very early season of 1933-1934 (8).

Fusarium culmorum was moderately prominent in the plots in the Alsea valley in late season but in the coast re-

gion as a whole it was very widespread being particularly destructive on spring oats in Clatsop County. The fungus is readily isolated from spore masses at the base of diseased plants.

Two species of *Helminthosporium* were frequently isolated from the black stromatic bases of oat culms in late season in the Alsea Valley on both spring and fall-sown oats. *Helminthosporium avenae* Eidam produced a medium gray to mottled darker growth on potato dextrose agar in which brackets or fans of leathery tissue formed against the glass container. All of the cultures of *H. avenae* fruited when grown on corn meal in flasks held at out-of-doors conditions in the fall and winter at Corvallis. The relatively light golden, cylindrical conidia were typical of *H. avenae* as illustrated by Dreschler (1). The Alsea report appears to be the only record of *H. avenae* occurring on the roots of oats. *H. avenae* is also common on the leaves of oats in western Oregon although seldom destructively serious.

Besides *Helminthosporium avenae*, another species, *H. sativum*, was isolated from wheat, oats and barley in the Alsea Valley. It produced a carbonaceous type of growth on sterilized cultures on *Melilotus* stems. The spores in twenty cultures were ovate and very dark. They resembled the conidia illustrated in Dreschler's plate 19 at C (1). A single exception to the dominant race in the Alsea plots had long ovate lighter conidia representing a less abundant but distinct race. The presence of *H. sativum* on oats is itself unusual and the presence of the dry land organism *H. sativum* is the humid coastal area is also interesting.

The take-all fungus (*Ophiobolus graminis*) which is a very important parasite on wheat in western Oregon and Washington is sometimes found on oats in the coast region of Oregon. Sporulating material of *O. graminis* was found on red oats in northern California in 1934 following the unseasonably warm winter of 1933-34. One 15-acre field that faced the open sea was heavily infested. Scattering patches were found at intervals north to Newport as well as inland in the Wilamette Valley. In general, oats seem to be susceptible to *O. graminis* only under very unfavorable growing conditions for the host. Oats are generally considered immune from *O. graminis* east of the Rocky Mountains.

Inoculation Studies.

Trials in the greenhouse with pure cultures of *Helminthosporium avenae, H. sativum* and *Rhizoctonia* sp. were made after the method employed in *Cercosporella* foot rot studies (9). Most of the studies were made with *Rhizoctonia* sp. and these have been reported in part.

Rhizoctonia sp. is a very active parasite particularly after the soil becomes warmer in the spring. Under the greenhouse conditions *Rhizoctonia* sp. attacked wheat, oats, barley, rye, spelt, *Lolium perenne, L. multiflorum, Holcus lanatus, Bromus rigidus, Festuca myuros,* and vernal emmer. Although the bent grasses (*Agrostis* spp.) are subject to attack from races of *Rhizoctonia solani* in Oregon, *Rhizoctonia* sp. isolated from *Avena fatua* and *A. sativa* did not attack *Agrostis tenuis* to any appreciable extent under greenhouse conditions and did not attackk *Agrostis palustris* at all in a duplicate experiment conducted in the summer of 1936.

Only one series of inoculations was made with *Helminthosporium sativum* and *H. avenae*. The usual inoculation methods (9) were employed, adding pure cultures of the fungi to Newberg sandy loam soil. *H. avenae* was negative on oats, wheat and rye. *H. sativum* attacked Huston spring wheat moderately and produced spores at the base

TABLE 1.—Relative resistance of cereals to foot rot and acid soil conditions in the Alsea Valley plots, 1930-1937.

Grain and Class	Varieties and indicated relative adaptability		
	Good	Fair	Poor[1]
Avena byzantina			
Fall sown	.....	Fulghum	Red Algerian
	.....	Kanota	Red Rustproof
Spring sown	.....	.....	Alber
Avena sativa			
Fall sown	Support	.....	.....
	Winter Turf	.....	.....
Spring sown	Anthony	Eclipse	Hajira
	Eclipse	Joanette Strain	Iowa D. 67
	Green Mountain	Markton	Richland
	Hawkeye	Rainbow	White Tartar
	Minrus	Schoolmam	.....
	Rusota	Victory	.....
	.....	Winter Turf	.....
	.....	Support	.....
Hordeum vulgare			
Fall sown	.....	.....	Alaska
	.....	.....	Olympia
	.....	.....	O. A. C. 7
	.....	.....	Winter Club
Spring sown	.....	.....	(All of Oregon grown varieties)
Secale cereale			
Fall sown	Oregon common	.....	.....
Spring sown	.....	Oregon spring	.....
Triticum aestivum			
Fall sown	Fulhio	Fultzo-Mediterranean	Fortyfold
	.....	Harvest Queen	Fulcaster
	.....	Leap	Kharkov
	.....	Oregon 100	Kinney
	.....	Ohio T. N. 1047	Pacific Bluestem
	.....	Thorne	Triplet
	.....	Trumbull	.....
Spring sown	.....	Huston	Galgalos
	.....	.....	Sonora
Triticum compactum			
Fall sown	.....	.....	Hybrid 63
	.....	.....	Hybrid 128
	.....	.....	Hybrid 143
Spring sown	.....	.....	Little Club
Triticum durum			
Spring sown	.....	.....	(All varieties tested
Triticum spelta			
Fall sown	Alstroum	.....	.....
	Bearded Winter	.....	.....
	Red Winter	.....	.....

[1] The list includes only a small part of those tested and which classify as poor.

of the culm on the blackened portion. *H. sativum* caused slight injury also on Fulhio wheat but none on oats and rye.

Grain seeded in Alsea Valley soil in October 1932 in the greenhouse became severely injured by foot rots by the end of winter. *Ophiobolus graminis Fusarium culmorum,* and *H. sativum* were found fruiting on wheat and barley in this experiment and *F. culmorum* on oats. The black "charred" stromatic growth was found on oats although the fungus failed to sporulate under greenhouse conditions.

Varietal Resistance Studies.

In the plots at Alsea Valley and at Astoria data were taken on both the fungi present and on the physiologic condition and development of the plant. All of the standard varieties of western Oregon cereals and also a large number of varieties and selections of oats furnished by T. R. Stanton, F. A. Coffman, and D. D. Hill were tested. Year by year the less promising were discarded and the surviving varieties or selections continued.

Counts of foot rot also were made at harvest time. It was found that the amount of foot rot at harvest time in the Alsea Valley was not always correlated with the adaptability of the variety. Many varieties were so subject to winter foot rots, the erosive action of winter rains, or to the combined acid soil complex that by harvest time much of the stand of a particular variety might have vanished, although the well aerated survivors were not heavily infected.

The relative adaptability of the cereals to acid soil conditions in the Alsea Valley is summarized in table 1. This considers both their resistance to fungi and to unfavorable environment.

In general, all but a few vigorous oats such as Eclipse are relatively susceptible to the serious *Fusarium* foot rot. Wheat is more susceptible to *Rhizoctonia* sp. than oats and both more resistant to it than barley. However, the disease is of relatively minor importance.

As indicated in table 1, fall-sown cereals are limited to oats, Oregon Gray and Support ,a similar winter variety. Fulhio wheat produces a fair crop as does Alstroum or Red Winter spelt. In the lower Alsea Valley, or where the light alluvial soils occur, it is doubted if winter grains should be grown. The tremendous winter rains cause heavy loss of surface soil as well as excessive leaching of nutrients. These, combined with root rots and foot rots, make the profitable production of winter cereals a gamble on these soils. At Astoria, brief trials indicated that the variety Support was possibly more resistant to winter root rots than the Oregon Gray Winter oat.

Further study is needed to determine the relative resistance of spring-sown oats to *Fusarium* foot rot. A number of varieties show promise of continuing to outyield Schoolmam oats which is susceptible to *Fusarium* foot rot although resistant to crown rust.

SUMMARY

Hay oats are attacked by a complex of soil-borne fungi which thrive in the acid soil of the humid coastal area of western Oregon. The most serious disease is *Fusarium culmorum,* but *Helminthosporium sativum, H. avenae, Rhizoctonia* sp., *Ophiobolus graminis,* and a number of other root and basal culm parasitizing fungi are associated with the cereal. The *Helminthosporium* spp. are considered weakly or doubtfully parasitic but *Rhizoctonia* sp. is a very active parasite. Wheat, barley and spelt are also parasitized by all of the fungi except *H. avenae.*

Winter cereals are not adapted to the lighter very acid coastal soils although Oregon Gray (Winter Turf) and Support oats are feasible in some places.

Fulhio wheat can be grown for grain but most other wheats and all barleys are mainly unproductive.

Spring-sown oats vary in their resistance to *Fusarium* root rots but further data and cooperative studies are needed to determine the best variety or varieties to grow. Schoolmam, an oat variety grown primarily for grain, while resistant to crown rust, is susceptible to root rots and should be replaced if hay oats resistant to both root rot and crown rust are developed.

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An Upper Cretaceous Florule From Northwestern Washington

ROBERT SMITH LAMOTTE
Oakland, California

Fossil plants previously recorded form the Chuckanut formation of Skagit and Whatcom Counties, Washington, have indicated Eocene age and led to the tentative correlation of this formation with the Puget Group exposed in the vicinity of Seattle. Preliminary study of a collection of fossil plants made near the base of the Chuckanut formation indicates the presence of the following species: *Podozamites lanceolatus, Sequoia concinna, Dryophyllum* sp., *Pseudoprotophyllum,* cf. *venustum, Ficus minima, Laurus coloradensis, Viburnum* sp. The last three species occur in the Vermejo formation of Colorado and the others are similar to species found in the Upper Cretaceous floras of Alaska. This florule shows that deposition of the Chuckanut formation began in Upper Cretaceous time while former studies clearly indicate that sedimentation continued without appreciable interruption throughout much of Eocene time.

Relation of the Forest Industry to Soil Conservation[1]

KENNETH DAVIS
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Forests are a crop; a product of the soil. Necessarily then, successful and continued production of forest crops is conditioned by the conservation of the soil and its maintenance in a productive state. Though obvious and self-evident, this should be kept clearly in mind as it is the fundamental relation between the forest industry and soil conservation. Up until the present, in this region at least, forest soils have largely been taken for granted and timber management methods have not been directly adjusted to soil requirements. Comparatively little investigative work on forest soils of an applied nature has been done in the United States, and practically none in the Inland Empire. I am not a soils scientist and cannot present you with a technical discussion of forest soils management. My purpose this afternoon is to outline general relationships between soil conservation and the forest industry, particularly as they apply to the Inland Empire region.

Economic Aspects.

The topic assigned, "Relation of the Forest Industry to Soil Conservation," suggests economic aspects rather strongly. As forestry and agriculture (including grazing), the two major uses of the soil, are also the two leading industries in the Inland Empire, the continued prosperity of the region requires the well-being of both and is dependent on successful soil conservation as the common denominator. I have become infected with the booster spirit of Spokane, and believe in the future of the Inland Empire. One can only guess what the Columbia River projects, for instance, will do for this territory. Many glowing pictures have been painted; if only a part of them come true the future will still be rosy. One thing is certain and that is increasing population and industrialization will place added demands on forestry and agriculture and hence on the soil.

Recently, I read an article to the effect that a broad reshaping of our national land policies, placing greater emphasis on the mountainous and intermountain areas, was needed. This meant a clearer recognition of the inherent advantages of the mountains in furnishing wood, water and to some degree protection from climatic extremes.

Perhaps this recognition is a little belated when one thinks of the so-called "dust bowl" areas. Many thousands of people have apparently reached the same conclusion more or less independently and without benefit of detailed surveys. Witness the present exodus from the dust bowl areas. The Farm Security Administration is making a survey of this, collecting data from various sources, and in the October issue of the "Land Policy Circular" they gave a short report. To quote: "Twelve thousand families, or approximately 60,000 persons, left the 'dust bowl' area of the Great Plains and settled in Oregon, Idaho, and Washington between January, 1936, and July, 1937. Conservative estimates report 7,400 drought families in 1936 and 4,600 in the first six months of 1937 as permanently or temporarily settled in the three states. Probably less than 5,000 are located on farms." This exodus or invasion, whichever way you look at it, has been going on for some time, too. Census figures, for instance, show as much

[1] Paper given before the Soil Conservation Section of the Northwest Scientific Association, December 29, 1937.

as a 50 per cent increase in the number of farms in some northern Idaho counties (the 50 per cent applies to Boundary County) between 1930 and 1935.

The exact figures are not essential. The point is that this population shift is taking place and that it is assuming very important proportions. As an immediate result it is intensifying and aggravating submarginal land problems in this region. Many of these new people, especially the later arrivals, are in poor economic condition and are settling wherever they can get any sort of foothold. Undoubtedly, many of them are settling, or trying to settle, on those very lands (frequently once forest lands) from which earlier tenants have been unable to wring a living.

What is the connection of all this with forestry and soil conservation? As I see it, it is two-fold. First, permanent economic prosperity for the region in general requires a stable, prosperous forest industry. An expanding population needs a liberal supply of forest products which cannot be purchased unless the people are economically prospering. Almost anything that improves their economic status will help the forest industry. You can put it the other way around too. A sound and prospering forest industry is a large contributing factor toward a stable prospering population. Personally, I believe that improved local markets are the real hope for better utilization of our so-called inferior species, at present a major timber management problem.

Second, some of the most acute forest soil problems are on these cut-over, often semi-agricultural lands. These lands are, by and large, the most abused and the most capable of being abused. They are the lower-lying lands, the most accessible, the most heavily cut-over, and in general are on the deeper, heavier, valley-bottom soils. Often, but not always, they are, potentially at least, the most productive of our forest lands. They are principally in private ownership. It is sad but true that the best of our forested areas have been treated the worst. Their rehabilitation is a major problem whose solution dips deeply into the soil beneath.

So far, I have attempted to sketch in very broadly some general relationships between the forest industry and soil conservation from an economic point of view. The gist of it is simply that the forest industry is inextricably bound in with the general agricultural and industrial development of the Inland Empire; that present and anticipated increases in population will intensify land management problems; and that remedial measures deeply involve soil conservation.

Effect of Timber Cutting Practices on the Soil.

I should like to pass now to a brief consideration of some soil conservation problems likely to be encountered in the practical management of commercial timber producing lands—not forest lands in general. I say "likely" because, as I said at the beginning, little is known of forest soil management in this region. Very possibly we have more of a soils problem on our hands right now than is realized. So far we have taken the soil largely for granted—a necessary something on which the trees grow. If European experience counts for anything, this idea will have to be radically changed.

The retrogression of pure spruce stands in Germany is a classic example of the effect of management practice on the soil. Most of you have probably read something of this. Early in the 19th century, or thereabouts, the growing of pure spruce became popular because of the high values that could be produced. Pure spruce stands replaced many native mixed stands of oak, beech, fir, and pine. These native stands

had been mismanaged and depleted to a considerable extent along about the time of the wars of Frederick and Napoleon, and reforestation with pure spruce was thought to be most profitable. Beginning with about the second spruce generation, however, distinct decrease in the rate of growth and general stand health was noted in many areas. This has been the subject of much investigation and the literature bearing on it is voluminous. The trouble, much of it at any rate, was found to be in the soil, and this may explain in part why the Europeans are so soil-minded today. It was forcibly demonstrated to them that the empiricisms of traditional management practice were not sufficient. Neither did the earlier more or less geological concept of soils fit or explain the observed facts.

Spruce, as you know, is a very shallow-rooted tree. It does not have the ability to force its roots down into or through soils that are not favorable to it, though it will penetrate fairly deeply into loose, friable, well-drained soils. Oak, beech, and fir, on the other hand, do have this ability and their roots go down deep. Roots are about the only natural means of loosening up the soil. Under shallow-rooted pure spruce stands the soil tends to become compacted. Aeration is impeded, drainage becomes poor, decomposition of duff is halted, and raw humus and consequent acidity builds up. As a result, forest soils that were once deep, friable, and crumbly have been changed in the course of a rotation or two into dead, cold, sterile, compacted, turf-covered, and often boggy, soils. Rehabilitation of such soils is very difficult.

Of course, all these dire things did not always happen; results were as variable as the particular kind of soil concerned and its precise treatment. Soil retrogression was often aggravated by various forest "rights," permitting utilization of duff and litter which caused soil impoverishment.

Somewhat similar difficulties have been experienced in stands of pure pine. In general, the swing is decidedly from pure to mixed stands. In European literature, one frequently finds mention of the underplanting of coniferous forests with beech and oak to create litter, loosen up the soil, and generally bring about a more productive soil condition. That pure stands often have an unfavorable effect on the soil, are more susceptible to disease, and in general are of poorer quality is rather common knowledge now.

In the western white pine forests, people often get the erroneous idea that we in the Forest Service are trying our best to grow pure white pine stands, and exterminate white fir and hemlock as forest weeds. This is not true. It is true we plant western white pine extensively and favor it strongly in stand improvement practice. White pine plantations do not necessarily produce pure pine stands, however; a substantial representation of other species usually develops from natural seedings. In timber sale areas, where most stand improvement work is done, the residual stand almost invariably contains many trees of species other than white pine.

Undoubtedly, there are "sick" soils in this region. Some of you have probably been in forest areas where despite apparently favorable site conditions the forest was making poor growth and in a generally unhealthy state. I have in mind particularly some areas in the Priest River valley. One of these is a low bench-land area on the Priest River Experimental Forest 15 miles north of the town of Priest River. What superficially at least appears to be a good timber growing site supports a slow-growing, unhealthy reproduction stand about 40 years old that seems very sub-

ject to disease. Yet scattering veteran trees remaining in this area have made good growth in the past. There is a distinct hardpan formation in this area which the tree roots seem to have difficulty in penetrating. This raises the interesting question: "Has this hardpan formed in comparatively recent years and, if so, why?" I don't know the answer.

In another area on Hannah Creek, a mile or so from Kalispell Bay on Priest Lake, there is another somewhat similar stand. The stand just looks "muscle bound," to use a descriptive if not scientific term. It is 200 years or more old but the trees are comparatively small in diameter and less tall than normal at that age. Decay is very prevalent; hemlock trees in particular are mostly just hollow shells. Similar appearing sites have produced much better timber. Again, an unfavorable soil condition is suggested.

I have often wondered what is happening to the thousands of acres of cut-over and burned-over bottom lands in the Priest River valley. Once, most of them supported heavy stands of timber. What has burning, exposure, and, in most instances, heavy grazing done to them? Have there been soil changes that will make reforestation a long, slow job even if difficulties in getting planted stock to survive during the difficult first years can be surmounted? Largely as an experiment, the Forest Service has planted ponderosa pine on some of these areas. The original stand in most cases was a mixture of western white pine, western hemlock, lowland white fir, western larch, and western red cedar. The hardy ponderosa pine is making excellent growth so far at least and it will either form a good timber stand of itself or at least provide a cover under which native species can develop that in the final analysis may prove to be the best adapted to the site.

Effect of Fire on the Soil.

Fire in the forest, either accidental or employed in controlled broadcast burning as a definite timber management measure, has been the subject of much critical investigation. It is of particular importance in this region as fire has to a large degree perpetuated the western white pine type. Although there is no unanimity of opinion as to the effect of fire, a few things seem to stand out.

In the first place, it is Nature's most usual method of reestablishing the stand. Fire has perpetuated the western white pine type by breaking up old stands which tend to become dominated by hemlock, white fir and cedar. One cannot side-step this simple fact.

Second, it is about the only effective means of physically removing large volumes of defective material from the forest. Fire also has some sanitary effects. It is the only means by which Nature, or man either for that matter, can effectively "clean house" and start over again.

Third, and here is where some of the sharpest differences of opinion may be found, burning has marked physical and chemical effects on the soil that, depending upon particular circumstances, may be either beneficial or detrimental. On the physical side, burning and the resultant removal of the forest cover tends to break down the soil structure. Organic matter is destroyed. Soils may become more compacted or lose their cohesiveness and become subject to leaching and erosion. These results are more pronounced with repeated burns. With single burns, such changes may not be appreciable.

On the chemical side, the immediate result of burning is the liberation of a greater than normal supply of several plant nutrients. Nitrogen is dissipated in burning, it is true, but better

conditions for bacterial growth in burned-over soils and the lush vegetation that usually follows fire promotes subsequent nitrification. The fertilizing effect of fire is traditional. The belief that burning forest and range lands stimulates grass growth is very old. Burning also cleans up the "rough" and tends to perpetuate a grass cover in the face of competing weeds and shrubs. You have probably observed the luxuriant growth made by grass, weeds, and shrubby plants in recent burns.

Development of coniferous reproduction also seems to be better on burned-over surfaces. A few years ago, Haig, formerly with the Northern Rocky Mountain Forest and Range Experiment Station, in studying seedling survival and development on burned and unburned surfaces at the Priest River Experimental Forest, found seedling growth at the end of the second year to be about twice as good on burned as on unburned surfaces. How long this stimulating effect will continue is not known. There is also some difference of opinion as to how much of a real benefit it is. It has been claimed that the increased supply of nutrients may leach away in a few years leaving the soil impoverished. I read a translation of a German article the other day to the effect that seedlings stimulated by an abnormal supply of available nutrients become less drought resistant. These results were obtained through laboratory tests, however. Under field conditions a somewhat greater susceptibility to drought would not be of importance unless drought were a critical factor.

General statements regarding the effect of burning in this region are difficult to make. Too little definite information is available. A sharp distinction should be made between the necessity for prompt detection and suppression of accidental forest fires as a matter of fire control policy, and certain beneficial or detrimental results that may result from fire in the woods, especially when used deliberately in controlled burning. It is of the latter that I speak. There is not one result of fire but many. The physical and chemical composition of the soil, the forest type, age, aspect, and the intensity and frequency of burning must all be considered and results will vary as they cary. On the extensive flats of the Priest River valley, double burns on the heavier, clayey soils (where everything is burned to red ashes) will give results very different from those attained on single burns on well-drained slopes where the duff is no more than scorched. Personally, I feel that, used intelligently and with discretion, fire in the woods is a useful tool that has a real place in timber management practice—a larger place than it has had hitherto.

Due to the lack of specific information on forestry soils relationships directly applying to this region it has been necessary here to be rather general and draw upon experience outside the region. I do not believe it is possible to go much farther right now. We need research in forest soils and need it badly. Much can be learned by analogy from other forest regions but considering the distinctly local nature of soils there is no substitute for local research.

In closing I'd like to leave these thoughts with you:

1. An expanding population in this region will both require and force better utilization of our soil resources for agricultural and forest production. So far we have been skimming off the cream; the job of maintaining a permanent and prosperous economy is just beginning.

2. Some of the most acute forest soil problems are to be found on so-called submarginal lands—lands bordering

between forest and agricultural uses. These are the lands that have been abused the most and yet include some of the most accessible and useful lands. They are mostly in private ownership. Classification is badly needed to determine which are suitable for agriculture and which for forestry. Classification must, of course, be followed by a constructive program of action.

3. Forest management practice can materially affect the soil. The more or less common idea that forest soils can perhaps be abused somewhat but not materially changed is vanishing and at present there is a rapidly increasing interest in forest soils research. Much has been learned about the physical and chemical nature of forest soils but to only a limited extent has research reached the point where it can be directly applied in forest practice.

Flake Graphite of Certain Xenoliths in the Colville Batholith

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On the west side of the Moses Meadows Basin, Okanogan County, Washington, in Township 34 North, Range 29 East, and well within the exposed area of the Colville Batholith occur sedimentary xenoliths now metamorphosed and carrying crystalline graphite in small (1 mm.) flakes and small linear aggregates.

The xenoliths vary in size from small chip-like inclusions to masses three or four-hundred feet in diameter. The xenoliths are composed predominantly of complex lime-silicate rock with some quartzite and biotite-quartz schist. In some places igneous gneiss, whose foliation parallels and whose appearance resembles the sedimentaries, makes up an outer portion of the xenolith. A peripheral zone of pegmatite and other acid phases of the granodiorite surrounds each xenolith. The principal metamorphic factors that affected the xenoliths were heat and silicification. Three types of lime-silicate rock are recognized and see mto represent different degrees of silicification.

The graphite occurs in the metamorphosed sedimentary rock, the intrusive acid stringers within the xenoliths, and the acid gneissic phases of the granodiorite close to the xenoliths. Carbon of the graphite was apparently derived from both organic and inorganic sources within the sedimentaries. It apparently suffered oxidation and reduction according to the reactions postulated by Alling. Migration prior to reduction is indicated by its presence in the surrounding granodiorite where it penetrated the granodiorite during all stages of its mineral crystallization.

From study of the intercrystal relations of the graphitic rock as well as from laboratory tests the following conclusions are reached regarding the susceptibility of the graphite to profitable extraction:

1. By extraction results and volumetric measuring the graphitic content of the metamorphosed sedimentaries is found to run from a trace to 8% with 2 to 3% being an average for the lime-silicate rock.

2. Flotation concentrate of 60 to 75% graphite with clean tailings can be readily made.

3. Cleaning the concentrate and marketing the product are the principal obstacles in the path of profitable production.

4. Marketing difficulties can be overcome only by the producer turning manufacturer.

5. The problem of cleaning the concentrate must receive much research study.

6. No number one (large) flake can be produced.

Chemistry in the Education of a Forester*

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INTRODUCTION

The sciences of physics and chemistry are concerned with the phenomena of the physical world, i. e., with all the materials and energies of the universe. The boundaries of these two sciences merge, and, in their broader aspects, they may be considered as one. Today physics is generally considered as the science of matter, involving no chemical changes Chemistry is concerned with the composition of substances and of their transformations. Chemistry and physics are, therefore, basic sciences whose laws and principles extend inexorably through all other natural sciences.

Living organisms are peculiar and uncommon (in a universal material sense) aggregations of materials. Their existence and behavior is governed and motivated by physical and chemical laws. Every cell and every organization of cells is a most delicate and intricate chemical-physical laboratory. The internal physical and chemical phenomena of living organisms, such as colloidal surface reactions, diffusion, capillary flow, organic synthesis, and delicate catalytic reactions are influenced by external physical and chemical factors such as temperature, light, wind, gravity, water, other living organisms, and the soil. Since a forest is a very complex association of trees, other plants, animals, and micro-organisms, the effect of external factors and of competition is most complicated on a forest community.

The problems with which forestry deals are highly diversified and require a broad basic training in the natural sciences, mathematics, surveying, and economics. Forestry is an applied science based on chemistry and physics, the botanical sciences, soils and geology, and zoology. Of the foundation studies for forestry none is more important than chemistry. A very excellent and concise statement on this subject is given by Graves and Guise[1] in their book on "Forest Education." I quote directly:

> "It is unnecessary in this report to discuss the reasons for providing instruction in chemistry and physics, either from the standpoint of general education or in preparation for the subsequent courses in forestry. The subjects are basic to all study of science. Our knowledge of the natural phenomena with which we deal in forestry in the final analysis is based on chemistry and physics. In these subjects the student is brought into contact with fundamental facts of nature, and he is given training in accurate observation, in the method of analysis, and in reasoning from observation. The acquisition of knowledge of direct service in technical work in forestry, the acquaintance with the profound truths of science that enables one to understand better the world about him, and the training in scientific method are all of importance in a preparation for the profession of forestry. These facts are generally recognized by the forestry schools."

NEED FOR CHEMISTRY IN THE PRACTICE OF FORESTRY

Although the reasons for instruction in chemistry as a preparation for forestry may be generally recognized, there is, nevertheless, considerable difference of opinion as to how much chemistry should be required and how it should be taught. Is one year sufficient or are more desirable? Should

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chemistry be taught to foresters in a thorough fundamental course as is required for majors in chemistry, or is general survey course more desirable?

Before answering these and other questions, let us examine the need for chemistry in the practice of forestry and in the education of a forester.

As Basic Education.

One of the objectives of education is to give the student a better comprehension of the world about him. Chemistry (and physics) acquaints the individual with the fundamental concepts and laws of nature. It gives him a better understanding and appreciation of the world of which he is a part. Therefore, chemistry should be an important part of any scheme of higher education. A law professor recently stated that chemistry should be included in the law curriculum, because many of the industrial and other cases which come up involve chemistry, and if the lawyer has no ability to understand and evaluate the chemistry involved, he is severely handicapped.

Now forestry is an applied science based on the natural sciences, including chemistry. Furthermore, chemistry is basic to all natural science. Chemistry, therefore, should be a part of the basic training of all foresters. It may be further argued that the training in the techniques of observation, analysis and reasoning obtained in chemistry are of vital importance and value to a forester.

In Silviculture.

The practice of silviculture is based on a knowledge of botany, particularly dendrology, ecology, and physiology, on pathology and entomology, and on geology, soils and meteorology. Training in the principles of chemistry is essential for a porper understanding of physiology, ecology, and soils. The chemistry involved in the growth and life processes of trees, the effects of environment on the biochemistry of the tree, and the chemistry of the soil and its relation to nutrition, growth, and the character of the stand are all essential to the intelligent practice of silviculture. The chemical composition of the soil has a very important, but as yet little understood, effect on the growth of trees and the nature of a forest. Certain chemicals are essential to growth, others have been recently discovered which, when added in exceedingly small amounts to the soil, greatly stimulate growth and even change the behavior of the trees.

The chemical changes taking place in humus, the effects of thinning, logging, and fire on the chemistry of a forest are other important factors to consider in silviculture. A more simple yet important application of chemistry to silviculture is the treatment of seeds by certain chemicals to hasten and stimulate germination.

It is not expected that every forester should be a specialist in soil chemistry or physiological chemistry, but he should know sufficient chemistry to understand, interpret and apply chemical data and make simple observations.

In Forest Protection.

In protection from fire, physics is more fundamental than chemistry. A knowledge of the effects of temperature, humidity, and other meteorological factors on the inflammability of duff are a direct application of physics. Chemistry, however, may play a part in fire control in the future. For example, chemical sprays might be used to check or retard fires. A recent article by H. R. Offord and R. P. d'Urbal[3] contains a discussion on the use of chemicals in burning wet brush piles. This holds interesting possibilities for controlled slash burning.

In forest pathology, a knowledge of chemistry is necessary for an understanding of the action of fungi and

other parasites on wood or other tree tissues. Control measures involve the use of toxic chemicals in many cases.

In Forest Utilization.

Wood is an organic tissue produced by biochemical processes from air and water. The soil furnishes the water and various essential catalytic chemicals. Wood is a very complex chemical substance, and is an important raw material for chemical industries. From wood there are manufactured by chemical processes pulp, paper, fiber boards, textiles, cellulose wrappers, plastics, solvents, acids, tannin, preservatives, charcoal, oils for paints and as chemical solvents, and many other useful commodities.

Chemical utilization of forest trees is an important part of forestry and will undoubtedly increase in importance in the future. The theoretical or laboratory possibilities for further practical developments in chemical utilization are most promising. Much research is being done over the world in wood chemistry. Since chemical processes deal with the minute units of wood, the fibers, the colloidal particles, and the molecules, wood wastes should be ideally suited for utilization by chemical means. A number of lumber companies and lumber associations are interested in the chemical development of by-products from their mill wastes and are surveying possible research programs. At least two companies in the West already have research laboratories and chemists working on waste utilization problems.

In the large and important field of preservation of lumber and timber products, a knowledge of chemistry is essential.

It is evident that chemistry is of vital importance to the specialist in utilization, even to the sudent who goes into commercial lumbering. The general forestry student does not need the detailed knowledge of wood utilizationist, but he should have sufficient knowledge of chemistry to understand and appreciate the problems and new possibilities of utilization of the forest.

In Forest Research.

Practical forestry must build on research. In fact, research should always be ahead of forestry for otherwise practice must move by rule of thumb, and such blind practice is frequently costly or even disastrous. Research is a large and important branch of the Forest Service and many other institutions are carrying on technical and scientific forestry research. Such research, to be carried out intelligently, must be done by men with thorough training in their specialties and with broad fundamental training in the sciences basic to forestry, among which chemistry is important for reasons already given.

In Forest Management.

A knowledge of chemistry is no criterion for a successful forest manager. But, nevertheless, a forest administrator who has a general understanding of chemistry is better able to appreciate and interpret certain data and problems with which he may have to deal. He will be in a better position to understand and apply the results of research work to the practical management of his forest areas.

NATURE OF TRAINING IN CHEMISTRY

The need for basic training in chemistry for foresters is apparent. However, there is considerable difference of opinion with respect to the nature and extent of chemistry courses necessary for foresters.

With the exception of certain specialized curricula, such as wood utilization, we cannot expect to teach more than the elements of chemistry. The usual requirement in most forestry schools is one year of general chemistry. In most cases, this general chemistry course is

the same for all groups of students, i. e., foresters, engineers, science majors, and others. In principle, this is as it should be. I shall elucidate this point.

Foresters, after graduation, go into a diversity of jobs. In some of these jobs, the value of chemistry may not be immediately apparent. In others, particularly in research, a knowledge of chemistry at once becomes useful. Some graduates train to become specialists, either by self-study and experience or by graduate work. Therefore, the undergraduate work in chemistry must be such that it gives the general forest production student sufficient understanding of the subject for the intelligent practice of forestry, and will also enable him to build onto this work without loss later on if he wishes to specialize. This means that if only one year of chemistry is required, as is usual, no more than the elements and basic principles can be taught, but this should be taught thoroughly. A special course for foresters (meaning usually a simplified course) or a general survey or laymen's course is undesirable and inadequate both in the subject matter taught and in the scientific methodology learned.

One year of chemistry is the barest minimum of preparation for a forester. Additional courses in analytical and organic chemistry would be very desirable preparation for studies in physiology, ecology, forest soils, and silviculture. However, the forestry curriculum is already so crowded with essential material that this is impossible. Instead of the standard second and third courses in chemistry (analytical and organic), a better arrangement might be to design a second year of chemistry for foresters to give them some understanding of organic chemistry and plant chemistry. At Idaho a second course of one semester duration was designed for agricultural students. In involves the elements of analytical and organic chemistry. We are now requiring our forestry students to take this course. A half-year course in plant chemistry should follow this. Such an arrangement would extend and apply the fundamentals of the introductory course to the chemistry of the tree. In a five-year curriculum, it would be possible to include these courses.

In discussing the deficiencies of forest education, Graves and Guise[1] point out that the most significant criticism by those best qualified to form a judgment is the lack of thoroughness in fundamentals. They also point out that many graduate foresters feel that their basic work was of little value. Analysis indicates that the trouble lies not in the inclusion of fundamentals and of the theory and principles of the subject, but lies in the fact that the work was not thorough or the training was poor in quality, or the student himself failed to take advantage of the opportunities offered by the school.

Our introductory fundamental science courses are, unfortunately, frequently deserving of criticism. More unfortunately, this criticism often results in a weakening of the course by curtailing theoretical work, emphasizing practical examples, and generalizing by teaching the subject as a survey course.

A common fault in the teaching of introductory chemistry and physics is that in the attempt to cover the ground, a great mass of factual information is handed out. This is because these subjects have expanded greatly in recent years and the instructor fails properly to organize the material. The student, even a good one, may fail to assimilate it and his mental powers are certainly not stimulated. Warren K. Lewis[2] of the Department of Chemical Engineering, Massachusetts Institute of Technology, in discussing the education of engineers, point out that students who are trained

in the above described manner " . . . have grandiose concepts but cloudy notions of their relations to the facts. Many a graduate student, who will talk glibly of the third law of thermodynamics, is unable to give any idea of the nature of energy or the reasons for assuming its existence, or will define temperature as what the thermometer reads." In other words, as Lewis points out, the acceptance of any of the knowledge taught is an act of faith and not an intellectual appreciation of its background and meaning.

A course in chemistry—or in any science—should be so taught that the student grasps the logic of the development of the scientific laws and principles from the facts presented. The logical development of theories from known facts given the student teaches him not only the facts and theories and the limitations of the theories, but trains the student to think logically along scientific lines. It develops analytical and creative thought which is important in meeting new problems in the profession.

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A Preliminary Report on the Eocene Flora From Franklin Butte, Oregon

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Outcrops of a sandy shale on the west and south sides of Franklin Butte have yielded an Eocene flora of approximately 25 species. The majority of the specimens are leaves of angiosperms with *Sequoia langsdorfii* the single gymnosperms. Among the angiosperms are some genera found in the modern temperate forests, as *Amelanchier, Ribes, Tilia* and *Vaccinium.* Other genera, as *Laurus, Ilex* and *Tetracera* are warm temperate to subtropical in distribution. Such an association probably indicates a warm temperate climate, not a subtropical one, with abundant rainfall and no frosts.

An Unusually Wide Zone of Crushing in the Rocks Near Kettle Falls, Washington

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Field Relations.

The rocks described below occur in a belt about twelve miles long and two miles wide, in eastern Ferry County, Washington. The northeast end of this belt lies directly across Columbia River from the town of Kettle Falls, its further extensions to the northeast being hidden by the schists and quartzites around the Falls. The southwest end of the belt lies beneath the quartzite and schist of Onion Ridge.

This belt of crushed rocks forms the southeastern margin of the Colville batholith,[1] in this part of its range. The contact is narrow between this crushed border zone and the older metamorphic series, but disappears under the Columbia River terraces near Mink Creek, to reappear just north of Sherman Creek. In contrast to the sharp-cut outside edge of the crushed zone, the inside edge, or that facing the center of the intrusion, is gradational into the uncrushed central parts of the Colville batholith. The strain phenomena in the western areas of the batholith, away from the border, are restricted to warping but not crushing of the minerals, and cannot be seen in the field. Though the apparent width of the zone of crush effects has been stated as two miles, its true thickness is much less; for the ridge-tops mark approximately the roof of the batholith, and thus the depth of the exposed batholith is limited by the depth of the valleys to about three thousand feet. No greater thickness of the batholith shell was seen anywhere; yet even along its roof, toward the west, no effects of crushing could be found, though thin-sections show that even these rocks have been under stress at some time.

Field Appearance of the Rocks.

The crushed border zone consists of straight-foliated blue-gray gneiss in most places seen, but there are yellow-white streaks and black streaks parallel to the foliation. The main gneiss is composed of close-set rounded white feldspars of all sizes up to an inch in diameter, but most of them under an eighth-inch. These granules are separated by thin black films along which the rock can split to expose their almost metallic luster and a sprinkling of small but sparkling muscovite flakes. The gneiss is therefore quite platy, and could almost be called a schist. Its foliation runs parallel to the contact between the batholith and the wall rock: in this area, the strike is variable northeast, and the dip southeast from fifteen to forty degrees.

In addition to the platy foliation of the gneiss, there is a pronounced linear element, or grooving. The grooves are narrow parallel wrinkles in the black films, and they trend almost due east with greater constancy of direction than that of the platy foliation itself. This eastward trend of the grooving carries it obliquely down the dip of the foliation.

The same foliation and linear structure are found in the light-colored streaks as in the gray gneiss, but many of the narrow black streaks show neither, though surrounded by strongly-foliated gneiss.

Borders of the Crushed Zone.

Contacts between gneiss and adjacent quartzites are of knife-edge sharpness; and the foliation and textures of the gneiss are no different at the contact than at a distance from it. The same is true of the contact between gneiss and quartz-biotite schist. Also, the schistosity of the latter is parallel to the contact and the foliation of the gneiss, but owing to the absence of

columnar minerals, no linear structure is apparent in it. These clean-cut wall-rock contacts are in contrast to the gradational inner border of the crush zone.

Structures and Composition of the Wall-Rock.

Only the part of the wall-rocks next to the border of the batholith are considered in this section, as they are quite different at a distance. They are a series of sedimentary rocks and lava flows which have suffered sufficient metamorphism to convert them into slates, greenstones and other low-grade metamorphic rocks. Next to the contact, their bedding is parallel to it. Locally these rocks and the sills included between them are folded into small overturns which lie back against the southeast-dipping contact, and pitch about 50 degrees to the southwest. Folds of similar orientation were seen in the foliation of the gneiss itself.

Two sills, larger than the rest, present a curious problem. One, about fifty feet thick, is separated from the batholith by two hundred feet of fine-grained quartz-biotite schist. The composition and foliated structure of this sill make its outcrops indistinguishable from those of the main mass. Above this sill are a hundred feet of black slate and thirty feet of fine-grained white quartzite, then the second sill. This second sill, if it really is a sill, is also fifty feet thick. Its dense black groundmass thickly sprinkled with small white feldspar crystals, makes it look a little like some sort of lava such as an andesite, but the crystals are aligned in bent and interrupted gneissic streaks, and the rock is full of tiny faults which displace these streaks a fraction of an inch or more. Thin-sections of this layer, described in more detail on another page, show apparently that it has the composition of granodiorite, and has been mashed to a remarkable degree.

At its top, this crushed layer grades into fifteen feet of dense gray flinty material containing yellow veinlets of the same texture and a little pyrite. Above this a gray limestone which accommodates itself to the blocky top of the flinty layer. The point to be noted here is that a hundred-foot layer of hard rock, some of it apparently thoroughly crushed, is sandwiched between soft rocks (a limestone and a slate).

Petrography of the Gneiss.

The main mass of the gneiss seems to be granodiorite, although estimates of the true mineral proportions are made uncertain by the fine grain of much of the rock. Much of the quartz is in irregular lenses, up to five millimeters long. The lenses are aggregates of ragged grains of quartz which will be referred to as "sutured quartz" because of the irregularity of the boundaries between grains. A few large ragged flakes of brown biotite occur by themselves, but most of the biotite forms irregular swarms of minute flakes interspersed with finely granular felsic material. Locally the biotite is partially or wholly turned to chlorite.

The gneiss shows all degrees of crush effects, from mortar structure (in which the grains are sprung apart and granulated on the edges) to advanced granulation which has reduced the feldspars to strained and rounded relics set in a mixed groundmass of fine particles, sutured quartz and one or more micas. Locally, and occurring together, are muscovite, garnet grains and apatite; and although the garnet and apatite are euhedral, the muscovite is locally bent around other mineral grains or cuts sharply across the rounded feldspars, the sutured quartz and the other micas.

White streaks in the gneiss are taken to be pegmatites or splites which have been sheared along with the enclosing rock. Their textures are now practically

the same as those of the darker main mass. These light streaks lack biotite and chlorite, but contain more muscovite and garnet than the dark.

Conclusions.

From the observations listed above, it is evident that a strong directed pressure left its marks on this part of the batholith, southwest of Kettle Falls. The brecciated appearance of the rock, the slicing and displacement of the feldspars, the warping of quartz and feldspars as shown by strain shadows, and the lens-like grouping of fine particles about rounded and strained relic crystals; all these are evidence of the pressure that has acted on the Colville batholith. The presence of muscovite and garnet suggests without proving dynamic metamorphism, as these minerals may be of igneous origin.

The east-west streaking, or linear structure of the gneiss means that the deforming force acted in that direction. But the complexity of the structures in the wall rocks, as yet not wholly worked out, necessitates basing conclusions so far obtained, on the evidence of the batholith and its immediate environs.

The extreme crushing of the batholith border must have been the result either of intrusion pressure continued through final stages of crystallization, or of orogenic movements of some later date. The uniformity in direction of the streaking, over wide areas, makes the second alternative more likely. Also, if the foliation was produced by movements of the nearly solid igneous mass as it was forced into place, the folds in the adjacent wall-rocks show that the igneous material must have moved eastward and downward: a condition possible only along the top side of a tongue-shaped mass being pushed eastward as a kind of thick sill. There is no independent evidence that the batholith is of this type. While the superposed linear and platy structure and the joint sets are not out of harmony with this explanation,[2] the abundant dikes and sills to be expected in the rocks to the east, are not present. Because of this, it is thought somewhat more probable that the foliation and crushing in the batholith are due to distinctly later forces acting from outside the batholith.

Crush phenomena of the kind described above, have been found in many parts of the world,[3] including an occurrence in Washington (a short distance up Columbia River from Wenatchee).[4] The resulting rocks, called mylonites, have been formed along deep-seated thrust soles in most of these places; in very few are there any such large masses of rocks involved as in this intrusion border near Kettle Falls.

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Sodium Secondary-Alcohol Sulfates as Spreaders for Sodium Chlorate Herbicides[1]

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The sodium secondary-alcohol sulfates recently recommended as penetrants by Wilkes and Wickert[2] have been tested and found satisfactory as spreaders for aqueous sodium chlorate solutions. Large quantities of sodium chlorate are used annually in the destruction of currant and gooseberry plants for the protection of white pine forests against blister rust (*Cronartium ribicola* Fischer); in this work the efficiency of chlorate sprays has been increased by adding these new alipathics as spreaders.

Comparative tests of the new spreaders and those previously used were based on (1) stop-watch measurements of the time required to wet equal weights of coiled cotton twine floated on the surface of the solutions, (2) ocular observations of the rapidity and uniformity with which freshly detached leaves of *Ribes Petiolare* Dougl. became wet when dipped in the solutions, and (3) spray treatments of vigorous 5-year-old greenhouse specimens of *R. petiolare* with dosages of sodium chlorate comparable to those now being used for the eradication of this plant.[3]

For use with neutral, slightly acid, or slightly alkaline sodium chlorate sprays (or with proprietary hygroscopic chlorate sprays) the various spreaders tested were rated in the following decreasing order of effectiveness: Tergitol[4] 7, Tergitol 4, Tergitol 08, animal glue, and ethyl alcohol. In concentrations of 0.01 to 0.1 per cent by volume of the aqueous spray solution, the superiority of the first named was especially marked.

As a result of these tests sodium secondary-alcohol sulfate has recently been substituted for animal glue as a spreader for the proprietary sodium chlorate used in large-scale field work in the chemical eradication of *Ribes petiolare*. Throughout the white-pine regions of northern Idaho and western Montana the destruction of this plant is particularly important because of its high susceptibility to blister rust disease and its part in spreading that disease to white pine.

In the large-scale eradication work on *Ribes petiolare*, 1 teaspoonful (about 6 cc.) of Tergitol 7 is added to each 10 gallons of spray solution, the latter containing about 6 pounds of effective sodium chlorate. Optimum dispersion of the spreader is obtained if it is added to the water before the weed killer is dissolved. In the spraying of freshly prepared solutions there is no apparent difference in wetting power between aqueous solutions of the spreader and its mixture with proprietary sodium chlorate sprays in the concentrations we have employed.

Sodium secondary-alcohol sulfates are relatively nontoxic to human or animal life, nonirritating to the skin, and noncorrosive to equipment used in spray work; they do not increase the fire hazard of chlorate sprays and may be stored in any glass or metal container. Their potency in lowering surface tension recommends them for field jobs where the weight and bulk of spray materials must be kept small.

The list given in the third paragraph indicates the relative effectiveness in neutral or nearly neutral sodium chlorate solutions of the five spreaders tested. If the materials are used with other common herbicides, the order of preference may be different; but the sodium secondary-alcohol sulfates should

remain the most satisfactory because of their stability in strongly acid or alkaline media, their resistance to the destructive action of oxidizing agents, and their solubility in hard water.

Wide variations in spreading properties may be obtained by increasing the concentration of the sodium secondary-alcohol sulfates in the aqueous spray solution. This type of spreader might be useful for the selective killing of plants which vary significantly in their external morphology, especially those susceptible to contact foliage sprays.

[1] Laboratory and greenhouse work have been made possible through cooperative facilities furnished by the Division of Forestry, College of Agriculture, University of California, Berkeley, Calif.

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[4] In this article the concentrations of Tergitol compounds refer to the aqueous products as marketed in June, 1938, and it should be understood that the Department has no control over any changes that may be made by the manufacturers of proprietary compounds. The commercial Tergitols are mixtures of several sodium secondary-alcohol sulfates in aqueous solution; according to Wilkes and Wickert (ibid) the Tergitol products may be represented by the formula R_2CHSO_4Na, where R is any primary or secondary nonfatty alkyl group.

Cause of the Asymmetrical Profiles of the Typical Palouse Hill

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The typical hill of the Palouse Hills Section is strikingly steeper on the northerly side than on the southerly side. The cause of this asymmetry has been conjectured upon and explained many times by numerous individuals. Prior to 1931 it was generally accredited to dune action. In 1934 W. A. Rockie attributed its cause primarily to snowdrift erosion phenomena more or less as suggested by Kirkham after Matthes.

The writer made one-hundred profiles from the topographic quadrangle maps and supplemented them with study of pictures. A few profiles were checked by pacing. In these profiles the distance between the divide and the north drainage position was found to average but 47 per cent of the distance between drainage "channels". Some profiles were taken across ridges or across hills on both sides of which the drainage lines were incised into the basalt; the streams thus being positively fixed against lateral shifting as far as it would affect the profile of the hills or ridges. These profiles with the incised streams showed the same general relations as others in which the drainage was not so incised.

Thus in the development of this profile, those erosive factors which sought to shift the divide to the south were outweighed by those geological factors that shifted the divide to the north. This northerly position of the divide is believed to be incompatible with Rockie's supposition that snowdrift erosion was the dominant factor in producing the asymmetrical profile, though it is assumed that Rockie is correct when he says that snowdrift erosion is the dominant erosive factor under the present system of cultivation.

Dune action coupled with unlike vegetation cover and unlike resistance to seasonal erosion is believed to have been the dominant factor in the production of the typical, asymmetrical profile.

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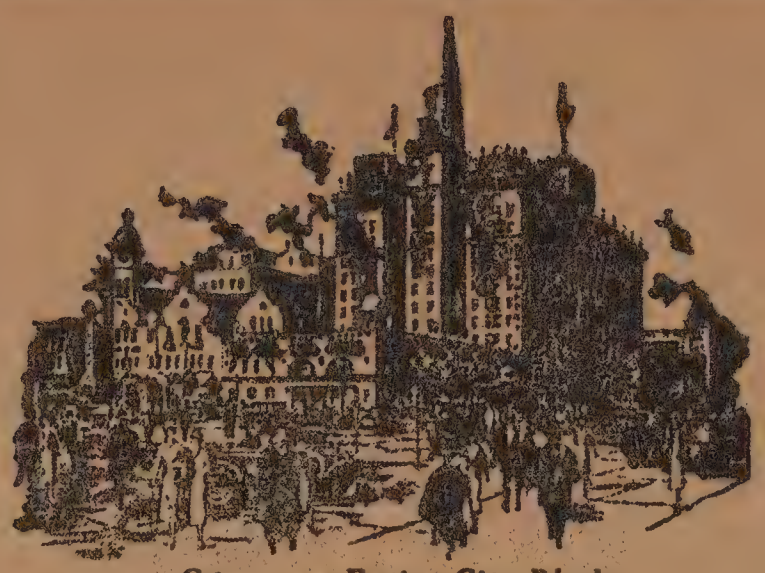

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The Fifteenth Annual Meeting of the Northwest Scientific Association

The fifteenth annual meeting of the Northwest Scientific Association, held December 28 and 29, 1938, at the Davenport Hotel, Spokane, Washington, had an official registration of 160, an increase of 12 more than the year previous. The usual visitors and guests swelled the section attendance to over 200.

The speaker at the opening general session was W. A. Rockie of the Soil Conservation Service and a former president of the Association, who spoke on the agricultural conditions and possibilities in Alaska. At the joint luncheon with the Associated Engineers of Spokane, the Washington Water Power Company's film on power development in the Pacific Northwest was shown.

Retiring President C. C. Todd, Dean of the College of Sciences and Arts, State College of Washington, Pullman, spoke on "The First Northwest Scientists," at the annual dinner. Philip H. Pope, Whitman College, gave the address at the Sigma Xi breakfast and showed pictures depicting the plant and animal life of the Tropical rain forest of Panama.

Aside from the general sessions section meetings were held for the following groups: (a) Bacteriology and Public Health; (b) Botany-Zoology; (c) Chemistry-Physics-Mathematics; (d) Education-Psychology; (e) Engineering; (f) Forestry; (g) Geology-Geography; (h) Social Sciences; (i) Soil Conservation, and a new section that plans on meeting from time to time with the Association, (j) Snow Survey and Hydrology. A total of 70 papers was presented.

Officers elected for 1939 include Dr. E. F. Gaines, State College of Washington, Pullman (agronomy), president; Dr. F. W. Gail, University of Idaho, Moscow (biology), vice-president; W. B. Merriam, Eastern Washington College of Education, Cheney (geography), secretary-treasurer, with J. H. Ramskill, Missoula, retiring president, and Dr. John Erlich, University of Idaho, added to the list of councilors.

Trustees elected included Dr. R. F. E. Steir, retained as chairman; Thomas Large, Spokane; W. A. Rockie, Spokane, and H. T. Gisborne, Missoula, for the one-year term. Dr. O. W. Freeman, Cheney, was chosen to continue as editor of Northwest Science, the Association's official publication.

The following section officers were elected:

Bacteriology-Public Health — Chairman, Miss Jacqueline Bahrenburg, St. Luke's Hospital, Spokane, Washington; secretary, Dr. Ernest McCulloch, State College of Washington, Pullman.

Botany-Zoology — Chairman, Dr. J. Warren Severy, University of Montana, Missoula; secretary, Dr. Leslie Headrick, Whitworth College, Spokane.

Chemistry-Physics-Mathematics — Chairman, John A. Carlson, Whitworth

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College, Spokane; secretary, Dr. R. W. Gelbach, State College of Washington, Pullman.

Education-Psychology — Chairman, Dr. O. J. Williamson, Eastern Washington College of Education, Cheney; secretary, R. F. Hawk, Eastern Washington College of Education, Cheney.

Engineering — Chairman, W. L. Maloney, Symons Bldg., Spokane, Washington.

Forestry — Chairman, Dr. E. R. Martell, University of Idaho, Moscow; secretary, Vernon A. Young, University of Idaho, Moscow.

Geology-Geography — Chairman, Thomas H. Hite, Soil Conservation Service, Moscow, Idaho; secretary, Ray C. Treasher, Oregon Bureau of Mines and Geology, Portland, Oregon.

Social Science — Chairman, Willis B. Merriam, Eastern Washington College of Education, Cheney; vice-chairman, Dr. Cecil E. Marshall, University of Idaho, Moscow; secretary, Charles R. Randall, North Central High School, Spokane.

Soil Conservation — Chairman, William J. Green, County Agent, Spokane; secretary, Sam L. Sloan, Soil Conservation Service, Spokane.

W. B. MERRIAM,
Secretary.

The First Northwest Scientists

C. C. TODD*

For fifteen years the Northwest Scientific Association has been fostering research in the Pacific Northwest. Some of the founders of our organization may rightly feel themselves pioneers in a significant forward movement, but no one, of course, thinks that collection of scientific data in this region began with the inception of our society. Perhaps few realize, however, that the scientific history of the Northwest dates back to the early eighteen hundreds and that the Lewis and Clark expedition and David Thompson's journeys in the Columbia River area made rich contributions to Science, not incidentally, but as the product of definite and detailed planning.

Credit for the boldly conceived Lewis and Clark expedition in all its aspects is accorded by everyone to that remarkably versatile and farseeing statesman, Thomas Jefferson. The political significance of the enterprise in connection with our westward expansion, familiar to all, needs no review. Its launching in 1804 was coincident with the transfer of the Louisiana Territory but similar plans, including the scientific possibilities, had long before been conceived in Jefferson's mind.

While Commissioner in Paris, he urged John Ledyard, an intrepid explorer who had sailed with Captain Cook, to travel by land to Kamtschatka, cross to Nootka Sound, thence down to the latitude of the Missouri, make his way across the continent to that river and down it to the then United States.

This somewhat fantastic adventure was actually begun, but Catherine of Russia changed her royal mind and, retracting her permission, sent her police to bring Ledyard back and dump him in Poland.

Not to be deterred, however, was Jefferson, who in 1792 proposed to the American Philosophical Society that a subscription be taken up to engage a competent person to ascend the Missouri, cross the "Stony" (Rocky) Mountains and descend the nearest river to the Pacific. André Michaux, a French

*The address of the retiring president of the Northwest Scientific Association presented at the annual dinner, December 28, 1938.

botanist who had studied American flora extensively, accepted the commission, but when he had proceeded as far as Kentucky, he also was recalled, in this case by the French Minister.

In 1803 President Jefferson recommended to Congress an appropriation for an undertaking to pave the way for commerce with the West by extending the geographical knowledge of our continent. The nation claiming the territory, said he, would regard this as a "literary pursuit" and thus "would not be disposed to view it with jealousy, even if the expiring state of its interests there did not render it a matter of indifference."

Oddly enough, in organizing the expedition, the President, in spite of his scientific objectives, did not include a scientist, or even a physician. Although neither of the co-captains, Lewis and Clark, could lay claim to either distinction, they both turned in remarkable performances in medical care of the men, the minutiae of scientific observation, and the systematic and accurate recording of volumes of data.

Meriwether Lewis, who at the time of appointment to lead the expedition had been for two years President Jefferson's Confidential Secretary, was regarded by his chief as having an aptitude for scientific study. Of the young man he said, "Guarded, by exact observation of the vegetables and animals of his own country, against losing time in the description of objects already possessed; honest, disinterested, liberal, of sound understanding, and a fidelity to truth so scrupulous that whatever he should report would be as certain as if seen by ourselves—with all these qualifications, as if selected and implanted by nature in one body for this express purpose, I could have no hesitation in confiding the enterprise to him. To fill up the measure desired," continued the President, "he wanted nothing but a greater familiarity with the technical language of the natural sciences, and readiness in the astronomical observations necessary for the geography of his route. To acquire these he repaired immediately to Philadelphia, and placed himself under the tutorage of the distinguished professors of that place, who with zeal and emulation enkindled by an ardent devotion to science, communicated to him freely the information required for the purposes of the journey."

Jefferson's instructions to Lewis, written in great detail in his own hand, constitute a remarkable scientific document. Exploration was given as the primary object. River courses were to be platted, longitude and latitude and compass variations were to be reported. "Your observations," said he, "are to be taken with great pains and accuracy; to be entered distinctly and intelligently for others as well as yourself." Furthermore the explorers were enjoined to make several copies of all notes to guard against loss, and he recommended that one copy be on "The Cuticular Membranes of the Paper Birch, less liable to injury from damp than common paper."

The Indian tribes were to be made the objects of scientific scrutiny, Jefferson listing some twenty-five points in this category. Lewis and Clark were to report also on soils; vegetable products; animals, "remains and accounts of any which may be deemed rare or extinct"; minerals of every kind, but particularly metals, limestone, coal, saltpeter. Volcanic appearances, climate, rain, clouds, sunshine, ice, snow, frost, dates particular plants put forth flower or leaf; times of appearances of birds, reptiles, and insects—these are only a few of the numerous details included by the President, apparently overlooking no scientific specification. After the return of the expedition he character-

ized it as having extended the boundaries of Science and presented to the people of the nation knowledge of "that vast and fertile country which their sons are destined to fill with arts, with Science, with freedom and happiness."

That the explorers executed this scientific commission faithfully and adequately is apparent even to the casual reader of the reports of their observations made more than 130 years ago. The material may be classified broadly under seven headings:

1. Geography.
2. Ethnology.
3. Zoology.
4. Botany.
5. Mineralogy.
6. Meteorology.
7. Astronomy.

It is not surprising to find that geographical features were described and mapped minutely. Every bend in the streams, every inlet, and bluff; the width, depth and clarity of the water; the soil, grass, timber—all these and more were recorded in the detail one might expect from men who had spent their lives in the open on the frontier.

The reader is amazed, however, when he examines the mass of data in the fields of biological science accumulated by these soldiers, untrained as scientists.

As the expedition progressed, each Indian tribe encountered had its census taken in a very thorough manner. The number of men, women, and children; the relationship to other tribes, habitat, disposition, religion, trade, hunting, disease, remedies, names and nicknames, were included in these compendious reports. Lewis and Clark were even prophetic enough to designate lands to which certain tribes might be removed to make way for the white man's civilization. The geographical and tribal names were recorded "as usially spelt and pronounc'd by the English." Considering the weird English orthography of these unschooled men, one wonders how nearly they came to a true representation of the Indian names. In some instances a vocabulary of the language was prepared with diacritical marks of their own devising to indicate the vowel sounds.

These itinerant observations on the tribes East of the Rocky Mountains were consolidated during the winter of 1804 at Fort Mandan. One copy of the tabulation sent back to the War Department was probably burned in 1809 or 1814; the second copy is in possession of the American Philosophical Society. In the winter of 1805 at Fort Clatsop at the mouth of the Columbia a similar accounting was made of the Western Indians whose numbers Clark estimated at 80,000 "Soles".

In addition to Geography and Ethnology, voluminous and significant contributions were made in Zoology and Botany, all the more remarkable because apparently so foreign to the training of the two leaders of the expedition. Entering as they were, however, a vast unexplored domain whose plains, forests, and streams were alive with species unknown on the Atlantic Coast, they could scarcely avoid discovering animals and birds new to science.

They have credit for first describing some of our now well-known animals, including the grizzly bear, three kinds of deer, the lynx of the Columbia which they called the tiger cat, and the mountain goat. At least three new birds were described, two of which perpetuate the names of the discoverers—Clark's Crow, Lewis's Woodpecker and the Louisiana Tanager.

On examining the volumes of biological data one is constantly struck with wonder at the painstaking descriptions. The writers lacked technical terms, but they apparently did not overlook a feather or a hair. For example a page of print is required to describe the white heron. Weight, length to a quarter of an inch, wing spread, color and size

of beak, color of eye and size to a tenth of an inch, length of each joint of the wing, number of feathers on each joint and length of each feather, number of toes and length of each, number of joints in each toe, and so on for every part of the anatomy.

Specimen skins were brought back and deposited in Peale's Museum in Philadelphia where they were prepared and mounted for exhibition and for the study of scientists.

The botanical contributions are no less numerous and important than the zoological, though one of the observers, Clark, in speaking of the fir trees near Fort Clatsop, says, "which I shall discribe as well as my slender bottonical skill will enable me." Lewis, however, freely uses technical botanical terms for the parts of the flower, leaf and stem of the plant.

Our familiar trees are minutely characterized; edible roots receive much attention, as do plants used by the Indians for medication. Prairie timothy seed and those of the Osage orange were among the many varieties preserved for propagation in the States.

An extensive collection of plants made on the way west and cached at the foot of the Rockies unfortunately was lost. A smaller collection made on the return journey, 155 plants, was turned over to the botanist, Pursh, of which not over twelve had been known by him to be natives of America. This scientist described 123 species from the Lewis and Clark collection, most of which he considered new. Subsequently, critical study has reduced the number, but approximately sixty-five of the species defined by Pursh in his Flora stand as such today to the credit of the amateur scientists. The Lewis and Clark specimens, mostly in fair condition, are now preserved in the herbarium of the Academy of Natural Sciences in Philadelphia.

The contributions in the field of Mineralogy seem not to be significant. Many observations were recorded and some eighty specimens were deposited with the American Philosophical Society. The nature of the most of them was unknown to the collectors, who, indeed, misnamed a number of common salts and minerals. Not lacking in scientific curiosity, Captain Lewis is reported to have been made ill by the fumes and taste of a substance he called "cobalt" and consequently "took some strong medicine to relieve him from its effects."

As to Meteorology, suffice it to say that a complete daily record of the weather was kept.

Determinations of latitude and longitude were made by the hundreds. An eclipse of the moon was recorded in all its stages. The instruments were few and simple—a sextant, an octant, three artificial horizons, a compass, a spirit level, and a chronometer. Apparently in the minds of the captains, the instruments differed in degree of usefulness or care required in handling, for while some were referred to as 'it," the sextant, octant, and timepiece were referred to with feminine pronouns. Thus of the chronometer, "She rested on her back in a small case prepared for her, suspended by a universal joint."

As pioneers in Northwest science, Lewis and Clark have "stood in the shadows of their great names" as explorers. It is in the latter capacity they are most widely known, the political consequences of the expedition looming largest in the public view, but we, as members of a scientific society in the region which Jefferson predicted would be filled with arts and with science, may profit from a review of the scientific phases of the enterprise.

Close upon the heels of Lewis and Clark there came into what we now call our Inland Empire another explorer,

David Thompson, who like them made initial contributions to Northwest science which were to prove of permanent value. In 1807, a year after Lewis and Clark had retraversed the Lower Columbia River following their winter's sojourn at its mouth, Thompson came over the Rockies through Howse Pass to the headwaters of the Columbia, the first of the fur traders to enter this territory. This explorer and geographer, practically forgotten for a hundred years, his discoveries unmarked by monuments, his grave unnoted, has only recently received a fraction of the recognition he deserves. With no other instruments than a sextant, a watch, a compass, and a telescope, he mapped with remarkable fidelity 1,200,000 square miles of our great Northwest. He is the only man to have surveyed and mapped the Columbia from its source to its mouth; for a hundred years the only white man, so far as the record shows, to have traversed it from its headwaters to the ocean. Five very active years were spent by this man in the region covered by our Association; five times, according to his journal, he visited Spokane House, the trading post nine miles down the river from the present city of Spokane. Because of his extensive explorations, his reports on the resources of the country, his numerous maps of astonishing accuracy, many of which are the only ones extant, and parts of which are included in every map showing the Columbia River, Thompson has been designated by Tyrrell and others as the greatest of the world's land geographers.

Born in London, in 1770, David was early left an orphan and sent to a charity school. On account of his interest in geography, he was, when fourteen years old, apprenticed to the Hudson's Bay Company in America. During this apprenticeship, in addition to performing his regular duties, he studied mathematics and astronomy, and at the age of nineteen, presaging his lifetime occupation, he was keeping a daily account of the weather and recording astronomical observations. Expected by the company to be a trader, he nevertheless made extensive surveys of the company's territory until ordered to desist by a short-sighted agent who demanded that full time be given to barter. The young scientist, not to be thus repressed, however, in 1793 transferred his services to the North West Company. Though still a fur trader, he was also the company's astronomer and geographer, and as we might now say, civil engineer, whose business it was to extend the territory, establishing posts, not empirically, but basing the locations on careful explorations and surveys. A man of tremendous energy and insatiable scientific curiosity, it was because he achieved so much more than the job required that he is being given recognition, belated though it is, among the early Northwest scientists.

From 1807 when he first crossed the Rockies to 1812, the year he retired from the company's service, Thompson with inexhaustible energy coursed back and forth across the Inland Empire establishing posts personally or through his men—Kootenae on the Upper Columbia, Kullyspell on Lake Pend d'Oreille (the first trading post in the Northwest south of the 49th parallel), and Saleesh House near Thompson Falls, Montana. Spokane House at the confluence of the Little Spokane and Spokane Rivers was built in July, 1810, antedating Astoria by eight months. Eastward over the Rockies Thompson went with furs and back again, discovering Athabasca Pass in 1811.

In all his journeys he never ceased his explorations and mapping, driving through the midst of greatest hardships of cold and near starvation, through terrific difficulties of navigation. The

hardy Indian and French-Canadian boatmen complained bitterly and deserted, worn out by his ceaseless activity. Knowing Astor's intention of establishing an American post at the mouth of the Columbia, Thompson assembled a crew and on July 3, 1811, embarked at Kettle Falls for the mouth of the river. At the junction of the Snake and the Columbia, near the site of Pasco, he planted the British flag and posted a notice to the world at large and the Americans in particular, "July 9, Tuesday, 1811. Know hereby that this country is claimed by Great Britain and that the North West Company of Merchants from Canada finding this Factory for this People inconvenient for them, do hereby intend to erect a Factory at this place for the Commerce of the Country around. D. Thompson."

As he proceeded he learned that he was too late to anticipate the Astorians, who had established themselves some months before. After greeting former North Westers now in the employ of Astor, he continued his surveys of the Lower Columbia and though disappointed in being beaten to the territory by the Americans he now had the answer to his prayer, entered in his notebook when he arrived at the headwaters of the Columbia four years before, "May God in His mercy give me to see where its waters flow into the ocean, and return in safety."

Thompson's narrative was not made available until 1916 when it was edited by J. B. Tyrrell, a Canadian geologist and geographer. "The Scientific thoroughness of this fur trader," says Tyrrell, "is astonishingly manifest in his ninety-four notebooks. His river surveys are unprecedented for their extent and number and have never been approached. This is true not only of the mighty Columbia and Saskatchewan but of every stream he travelled. For instance, three pages of the record of his descent of the Kootenai River gave eighty observations, each worked out by latitude and departure to show the exact course of the river over thirty-six and one-half miles. Never having been there before, but having studied Thompson's notebook, one could sit in a canoe and tell his companions exactly what turn they would come to and the length of each."

Years before learning of Thompson, Tyrrell had constantly noted the phenomenal accuracy of government maps of the Canadian Northwest and it was only after long search he discovered that the data originated with Thompson nearly a century before.

Like Lewis and Clark, Thompson reported on mineral and timber resources of the country, geological features, the extent of the Indian tribes, their vocabularies, the game animals, and many other items of scientific interest. He referred to himself, however, as an astronomer (the Indians called him Koo-Koo-Sint, the star gazer). His principal contribution to science is in the form of geographical data and maps preserved in Canadian archives and in the British Museum.

To quote Thompson's reference to himself, "Nothing less than an unremitting perseverance bordering on enthusiasm could have enabled him to have brought these maps to their present state; in early life he conceived the idea of this work and Providence has given him to complete, amidst various dangers, all that one man could hope to perform."

The names of Lewis and Clark have been perpetuated in historical accounts; they are attached to birds and flowers; great hotels and schools are named for these explorers; cities and rivers bear their names. Thompson's name, how-

ever, until recently has been little known. Upon the maps it is seen but seldom—Thompson River, Thompson's Prairie, Thompson Falls. Here and there monuments have lately appeared; his grave in Montreal was marked in 1926. Although a great deal of Thompson's exploration was in the present state of Washington, there is not within its borders, so far as the speaker is aware, a single geographical feature bearing his name or a monument commemorating his accomplishments. Nine miles from the meeting place of this Association is the unmarked site of Spokane House, its history unknown to the passing thousands. What more fitting memorial could be erected by the Northwest Scientific Association than a monument to David Thompson on that site which he visited so often, calling to the attention of posterity the achievements of this early Northwest Scientist?

The waters of the Columbia River now being held in check by the Coulee Dam will soon form an extensive lake, covering a part of the area first surveyed by Thompson. The interesting suggestion has been offered that the pioneer work of this explorer and geographer be further acknowledged by naming the new body of water Thompson Lake.

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The Affinity Between Cattle and Creek Bottoms on Mountain Ranges, and Some Effects Thereof

By EVAN W. KELLEY
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My subject is elementary in character, and its significance obvious. So much so that its presentation to a group of trained observers and men whose services are marshaled to the cause of preventing destructive land-use methods and the healing of land sores, in fact is a bit embarrassing to me. To do so is somewhat akin to a pupil telling his teacher that a boy sneaked a poke at his pal in school; bad behavior—preventable by throwing both boys out of school.

However, since the request was made there must be at least one good reason behind it to justify taking your time for the minutes that I shall stand before you.

Believing that this is the case, here comes my story:

Most members of the Bovidia family by nature are valley-loving creatures—flat, near flat and rolling land, by preference, their habitat. True, there are exceptions—wild sheep, goats and ibex, as examples; however, the easy topographic choice holds good for all heavier members of the genus, although some breeds have developed greater mountain-climbing tendencies than others.

Out of the instinct of cattle as a class to gain their livelihood with the least expenditure of physical effort and to rest in greatest comfort, springs one of the critical issues and most diffi-

cult problems incident to foraging of cattle on typical mountain ranges of the West.

Other factors complicate the problem—one, the more common presence of readily usable water in the bottoms than on the slopes. Still another is the habit of cattle between feeding periods to bed near their drinking places and to seek the shelter of brush or timber in creek bottoms for protection against the activities of predatory insects.

Accordingly, few mountain ranges characterized by long, abrupt slopes bisected by low-lying, relatively flat creek bottoms, small valleys and even steeper lateral water courses are without bottom land sores of varying degrees of cover and soil degradation.

Commonly, the sores are of long standing; a few are slowly healing under intelligent treatment; but many continue to suffer loss of cover and sluff precious soil into the water courses during the seasons of rapid run-off of precipitation.

Somewhat similar conditions are common on ranges of whatsoever topography where open parks intermingled with timber comprise a minor portion of given areas over which cattle graze.

I list some of the more obvious of the items of damage:

(1) Destruction of perennial plants of high forage value whose long, thick, deeply penetrating, soil-binding roots lead water into the earth, and their replacement, if any, by shallow-rooted annuals of low or no forage value; also, annuals are far less effective in minimizing rapid run-off of water and as soil-binders.

(2) Killing of browse—aspen—birch—willows—poplar—other brush and tree species common to deeper soils in given localities, with the consequent loss of the soil-binding and water-leading properties of the roots of such major plants.

(3) Breaking up of the sod, followed by sheet erosion and formation of small gullies, both of which lead to deeper lateral gullies, and viciously gutted main stream courses—many of which take the form of miniature Grand Canyons.

(4) Swampy land, grass-covered in its natural state, trampled into unsightly mud puddles, or "cow biscuits."

(5) Water-retaining capacity of bottom land—natural underground reservoirs greatly decreased, and in many instances completely eliminated; accordingly, their natural restraining influence against rapid run-off is replaced by water wastage and silt flowage.

(6) Ever-enlarging destruction of high-class vegetative cover extending up the slopes from the damaged bottoms, accompanied by all the evil influences incident to this form of resource degradation.

(7) Impairment of aesthetic values, and in many instances elimination of recreational values.

The extent to which the course of such damage has been run, to be sure, is not uniform in all places. The general pattern, however, does not vary. At the outset, damage is slight. Even some paid observers fail to see what they look at in this respect, and nothing is done about it. From such beginnings the depletion spans the entire gap between the incipient wounds where the degree of stocking has been light under reasonably good management, to complete wreckage on the longer and more heavily used areas.

I have seen in all western states

broad upland one-time meadows laid barren and reduced to gully-ribbed dust beds by the mouths and feet of cattle. I have seen smaller valleys converted to boulder-strewn flats by the same agencies of destruction. I have seen lesser grassy glades bordering mountain streams washed away until only their sloping foundations remained to form a part of the continuing incline from the hilltop to the bottom of the now stony stream beds, dry in summer.

I have seen sites where cows have completely eliminated aspen, willow, cottonwood and associated browse species by persistent feeding on seedlings and root shoots, and cropping of and rubbing against the parent stand. As a result, I have seen beaver—one of the most useful and interesting of animals—starved out and forced out. A more complete upsetting of natural ecological conditions is exceeded only by the smelter-fume poison which laid bare the Ducktown Basin of eastern Tennessee.

If all this is true, then why tolerate cattle grazing on areas where such form of destruction is likely to start, or is under way. I shall try to make a case for it. Here is one answer:

In the first place, the risk of such major damage continuing can be averted if proper control measures are applied. Secondly, use of mountain ranges by cattle has a place in the basic economy of many parts of the West, provided it can be conducted on a long-time basis without material injury to cover and soils. Thirdly, some small sacrifice of values in bottoms may be justified in order that the resources of a greater area can be made available for the benefit of mankind. It is a matter of balance-striking. Tricky—yes; and, in fact, in the past, doubts have been resolved too often in favor of the day-to-day benefits of the current year to current users without thought about the long-time implications of such practices.

Be that as it may, it is to be borne in mind that land has for humans only one purpose; that is to serve mankind most richly, and enduringly so.

To that end, what can be done to secure utilization of sidehill forage and at the same time heal the creek-bottom sores and make them again productive?

Each area has its particular problem or problems. Remedies should be selectively applied, and the selections ought to be medicines giving greatest promise of arresting spread and curing the running of given sores. Even carefully selected measures, skillfully applied, cannot be expected to develop absolute prevention of damage, but they can be made to operate as effective prophylaxis. Here are some suggested practices from which selections for given situations might be made:

(1) Determine a stocking limit which takes into proper account the natural impulse of the average range cow to live on the low lands, and the extent to which such inherent habits might be broken up if the animals are led away from bottoms by salting them well up along and on the crests of slopes. Put such determination into effect.

(2) Where prospects of its presence are good, develop drinking water for stock high up on the slopes and at the heads of water courses.

(3) Require daily herding of cattle to insure their proper distribution—a feature containing generous promise in fiction but far less in fact.

(4) Exclude stock from bottoms by fencing, permitting access to water at places where probability of damage by trampling is the least.

(5) Fencing of traveled lanes leading from the slopes to bottoms (cattle are prone to follow well-defined trails) with deflecting wings on the ends of the fences.

(6) Alternating use of given sections of range—that is, resting areas—and grazing them at intervals of one year.

(7) Killing off old cows—the dyed-in-the-hide creek-bottom habitues—around which younger stock gravitate, and which early absorb the bad habits of their leaders. The disposal of old "hardheads" lends more promise to the effectiveness of herding.

(8) Changing breeds of stock; for instance, the Black Angus breed is characteristically a better climber and rustler than the Shorthorn, or even more energetic than the short-legged, heavily-bodied Hereford—reputedly a hill-climber having great ambition for high places. However, with the breeding out of the longhorn blood, the modern vintage of this popular breed has become progressively more logy and often degenerates to the shabby genteel, creek-bottom scavenger.

(9) Changing classes of stock; that is, from cattle to sheep. Sheep can be placed where man wills for such length of time as he wills and in such formation as he wills. They can thrive without loss of weight for days—running into a week or more—without water ,the length of time between necessary drinks depending upon the succulence of the forage.

In passing, I cannot resist recording that certain areas have been used by cattle, and by sheep also, the soils of which by their very nature have such low "wearing" qualities as to render them entirely without use endurance for grass production under the pulling force of the jaws of the four-footed crop harvesters and the pushing, sliding force of the feet of such animals. In the first place, stock never should have been placed on soil so young and mobile; and secondly, if cover is to be maintained at all on such land and its soil is to be kept in place, stock needs must be removed entirely.

Returning to my subject—the stream-bottom problem: Where stream-course lands have been injured, their reparation enters the field of soil conservation activities. The means and the techniques appropriate to particular situations as practiced by the Soil Conservation Service and other agencies are applicable. I need not take time to enumerate before this group either the means or the techniques.

In the final analysis, use of typical mountain ranges by domestic stock can endure over the long swings only under the most skilled management, which takes into account not only the nature of the beasts using the range, but the nature of the soils upon which the feed grows, and the basic laws underlying the life's history of the plants.

The neglect of any one of these factors will lead in all instances, as it has in many in the past, to resource depreciation; and, if it goes on long enough, to plant destruction. With plant destruction follows rapid run-off, and, with that, comes an unraveling world, carrying along with it economic decline and impairment of civilization.

An Opportunity for Profitable Aquiculture*

THOMAS LARGE

To the scientist seeking a field for promising research, Central Washington has to offer two hundred and fifty miles of opportunity, extending from the Canadian Border, by way of the Columbia River, the Upper and Lower (Grand) Coulee, Moses Lake, Goose Lake, and back to the Columbia River at Beverly by way of Crab Creek. Changes inaugurated by completion of the Grand Coulee Dam and by watering 1,200,000 acres of land for agriculture besides establishing an enormous rural and urban population in the region, will create endless new situations favorable to aquatic and land communities of living creatures, both plant and animal, which if left to nature will slowly develop populations suitable to the environment.

However, to man bent on managing the processes of nature to his own advantage an unparalleled situation is presented. Near the southern border the "potholes" area of many square miles will be changed by waste water from irrigation, and by the rise of water level, from temporary to permanent ponds and lakes which with the development of aquatic vegetation will greatly extend and improve what has been described as a paradise for wild-fowl. Accompanying these wild-fowl, no doubt other aquatic life, as muskrat, beaver, and other furbearers, together with a land fauna of deer and possibly other wild game, can find vast areas for range with abundant food. All of these situations offer opportunities for proceeding in the most approved manner for development of proper plants for shelter, control of population of predators and food types of fish, introductions of crustacea and all that goes with the application of the science (if at such a stage it has arrived) of aquiculture. With fishable waters disappearing elsewhere by "improvements" of man, here the improvements seem to actually offer opportunity for improvement on nature. Crab Creek, flowing westward to the Columbia River, can scarcely escape becoming a sizable river. A possible river under biologic control for most of the factors governing its productivity!

Northward, in the Upper Coulee, an earth dam will retain in temporary storage the waters for irrigation pumped from above the dam in the Columbia River. Here possibilities are difficult to predict. The major purpose of this lake is like that of hundreds of other western irrigation reservoirs. Water, high in early summer, drawn down for irrigation by mid-August and remaining through the winter dry and frozen in the shore area which should be the main source of food for water birds and fish. With the spring melting of snows, flooded, and the creatures of the low-water line drowned, again decimating the food supply. If it can be included in the plan of conservation to refill this lake in autumn, or still better if the great pumps at the dam be utilized to keep its water level practically constant the possibilities of this lake are increased to enormous possible capacity for production, and commercial fisheries may add to the value of this great development.

But, it is the great lake above the Coulee Dam which offers most attractions to the conservationist. The lake itself is a great asset to a semi-arid region. It occupies a narrow valley which in itself now offers little productivity. It offers means of much needed transportation. From Little Falls on the Spokane River is a straight line distance

*Read before the Biology Section of Northwest Scientific Association, Spokane, Washington, December 28 and 29, 1938.

of forty miles to the rail-head at the Dam. A similar measurement from the head of the lake at the Canadian border is ninety-five miles. The meandered distance between the latter points is one hundred and fifty-one miles. The shore-line approximates six hundred and fifty miles. Bench lands along the shore of this lake can be made productive of agircultural crops by pumping, with present prospects that it may be done with electric current at low cost. One envisions here a lake and region not unlike the Okanogan of not far distant British Columbia, which has charmed so many visitors. The growing population of central Washington will here escape the excessive temperatures of midsummer by cruising on the lake or living in summer homes on its shore.

But here is one of the most interesting circumstances: The irrigator of the Northwest likes a constant flow of about one second foot of water delivered at his headgate if he is farming eighty acres of land, through the irrigation season of four and one-half months. This gives a total depth of water of about thirty-six inches over 80 acres in the season. Perhaps none too much where evaporation is so rapid as here. The snow-melt in the mountains within the drainage basin of the Columbia River furnishes a quantity of water closely approximating the demands of the 15,000 eighty-acre farms within the proposed area to be irrigated. Since this melt comes about the date the farmers need the water, we have an unique thing in storage basins for irrigation. THERE WILL BE PRACTICALLY NO "DRAW-DOWN" of the water level above the dam!

This means then that there will be as nearly as possible ideal conditions —for the development of fish food, or food along shores for water-fowl, for transportation conditions, for irrigation of bench-lands, and, for summer homes and pleasure cruising. A possibility of a destructive "draw-down" in winter may develop if over-ambitious power developments below the big dam are permitted to utilize the water retained above the dam at time of mid-winter water scarcity. It is here that conservationists must stand together to resist such destruction. Until there is within our government a coordinating agency empowered to balance all values concerned, and, with power to prevent developments prejudicial to other interests, those who appreciate the values coming from full use of water will be obliged to stand together to repel private interests that have in the past placed private profit above interests of the general public.

Research Needed.

The student of hydrobiology or the worker in the developing field of "aquiculture" will see many reasons for an extended program of research prior to and after the completion of the great dam and the distributing canals. Few will deny the need but it may be difficult to find any agency ready to assume the burden of financing the program. Numbers of Federal and State agencies have direct interests but they are occupied with matters which seem more immediate. Their activities must of necessity be limited to the purposes for which appropriations have been made, and the appropriators of funds are not given to "the forward look." Science is still dependent upon efforts and sacrifices of its devotees for the most important of all research, not to prove or disprove disputed opinions but to advance into that area beyond the border of the known.

Some types of research cannot go forward without support of great resources. Fortunately some other types require little more than sufficient curiosity on the part of the investigator to

devote his spare time (and not infrequently his cash which he can ill spare) to satisfying curiosity. To most workers of this group research becomes a game of solitaire.

Funds for this type of worker are not wholly wanting, as witness the small sums annually disbursed for such purposes by the Trustees of Northwest Scientific Association. But the funds needed for a thorough survey of existing fauna, flora, physical and chemical conditions of waters in the areas to be affected by changes now in progress, though comparatively small are greater than our own organization is now able to provide. However, this offers a field for investment for returns in local betterment. Workers are not wanting who are willing to invest their spare time or vacation time if they can get equipment and unusual expenses paid. The opportunity is here and only the support of wealth is lacking. A part of the personnel of such a project can be recruited from graduate students seeking work which can be used to advance them toward preparation for life work in these fields of science. Others may be found among those with training, whose summer vacations permit field work of this character. Senior and graduate students in our colleges may find biological departments ready to recognize summer work in this field.

The field work of the U. S. Bureau of Fisheries, while directed chiefly, perhaps, in the direction of investigations looking to suitable conditions for planting fish for the sports fishermen, have prepared field instructions for lake and stream surveys which should serve as a basis for other field parties working in these lines, and could be adapted to special needs.

The Biology Section of Northwest Scientific Association, if it should interest itself in this field, could do much in the way of aiding in the correlation of the work of investigators, preservation of records of work done, aiding in unifying objectives sought, conserving the results in way of materials collected. It could also aid by interesting competent workers to give time to the work, and possibly in some instances secure funds to finance the purchase of equipment. A committee of competent workers accustomed to field work of the character involved could aid in outlining field plans and suggesting the nature of equipment needed. To many unaccustomed to field work mere suggestion of things they may be able to undertake may lead to successful work in unexpected ways. The conversion of a strictly laboratory scientist into a field investigator may at times be difficult, but if he is a good sport and looking for a new diversion for his vacation such an undertaking may bring happy surprises.

The Board of Trustees of the Association can serve well in caring for the proper expenditure of any funds which may be advanced for such work. By its wide field of selection of workers it insures quality of results to be expected. As its workers are on strictly volunteer basis and working without pay, happy to be able to secure enough to purchase certain needed items of equipment or possibly traveling expenses, a donor may feel that he is cooperating in advancement of science.

The great lake to be established is in several respects unusual. In the first place the river carries little sediment. It is a clear stream even at flood. As it flows swiftly from melted snows in high mountains the lake will be cold. Its population will be largely downstream migrants. For this reason the study of the fish population of upstream lakes may be important. Will migrants of suckers and squawfish or of predators like pickerel and muskelunge fill the lake and make impossible a popu-

lation of valuable food and game fish? Will the present stock of "sockeye" salmon find suitable environment in this lake as they have found in other deep inland lakes where under the name of "Silver Trout" they have been planted and found to thrive and even rival or surpass their sea-going ancestors? Or will it be possible to introduce the Great Lakes Whitefish with sufficient success to develop here a great fishing industry such as prevailed in the Great Lakes in earlier days?

Addenda.

Since the above paper was read there seems a developing interest in the research work here proposed. The writer has been pointedly told by one national scientific leader that this is a really important piece of research and that it is up to the scientific people of the Inland Empire to carry it out and that the natural agency to handle it is the Board of Trustees of Northwest Scientific Association. As it is not a mere summer's work, no time should be lost. An organization of volunteer workers needs to be developed, composed of those with training in some of the lines of work required, or desirous of obtaining experience in such work. Some funds not now in sight for this summer's work will be needed for purchase of equipment. Some items of such equipment require an absurd amount of time for their procurement. Anyone desiring to make contribution, of any amount, may send it to Dr. R. F. E. Stier, Chairman of Board of Trustees, Northwest Scientific Association, Paulsen Building, Spokane, Washington.

Until such time as a competent and willing director is found, communications from biologists, or students hoping to secure training in lines of field ecology, may be sent to the writer at East 1528 Eighteenth Avenue, Spokane. Fundamental training in botany, zoology, chemistry, physics or physiography are desirable. More or less knowledge of all of these would be best. Student conferences with college authorities, looking toward credit for college degrees may be desirable. Week-end field conferences from time to time through the spring may possibly be arranged where some idea of the areas to be worked and possibly some practical field experience may be obtained.

Important as the results of this tentative program may seem, it is well to make it clear that little can be done without some source of funds for equipment, if not for some portion of field expenses of volunteers, is found.

Unless competent direction for this enterprise should develop from among our Northwest colleges a major item of expense required for the success of this enterprise may be the salary of a leader, for whom we may need to look to the states where active work along the lines needed has been done: Wisconsin, Michigan, New York and Illinois.

Practical Erosion Control as Applied to Grain Growing in the Palouse Country

By GORDON KLEMGARD

The conservation engineer has a definite problem of preventing the movement of soil by water and wind erosion. His associated problem in this is to do the job as perfectly as possible within allowable cost. If we confine our thought to the farmer operator of eroding lands we have a distinctly different point of view, which is the economic, or business man's, angle. In applying soil control practices, the operator is guided by the best engineering methods, but first of all he must take into his account all the factors which, when summed up, will answer the question: "Will it pay?" Whether any scheme of farming or the conservation of the farm will pay will resolve itself into two divisions for study—first, the short-term view and, second, the long-run view. This paper will consider the first only.

A study of the problem of soil conservation in the Palouse country will go back to the history of the early cultivation of the soil, and it is noted that this country is relatively new in cultivation but rapid in the rate of erosion growth. Most of the soils around Pullman and Colfax were under cultivation by the middle eighties, as the farmers had been moving into the area in the seventies. The land in our neighborhood rapidly felt the plow in these years. My grandfather broke sod on his place in 1882 and by 1900 my father had noted that on certain years there was some washing of the hillsides where winter wheat had been sown on summer-fallow. Even this early, the summer-fallow practice was well established. By 1915, I became personally aware of the rapid rate of increase in the size of the ditches and the amount of the silt that was deposited at the foot of the slopes each spring. As an operator of some of my father's land near Pullman, in 1918 I was definitely charged by him to adopt every possible practice to avoid soil damage by water erosion. Note the cultivation was then only thirty years old. He advocated plowing the heavy wheat stubble into the soil but the combined harvester, the adopted method at that time, left such heavy stubble that plowing was virtually impossible. The straw was then burned before plowing. The increasing rate of erosion as of this period can be, in part, definitely attributed to the application of the combined harvester to wheat growing on summer-fallowed land.

The Soil Erosion Experiment Farm was set up by the Federal Government near Pullman in 1931. Engineers in charge of this plant went rapidly to work and within a few year had made the people of the area erosion conscious. They soon accumulated some practical knowledge of effective methods of control of washing. They told of the heavy loss of crop foods from the soil. They explained that the summer-fallow practices were perhaps the best way to get the soil off the hill and down into the valleys. They called attention to and taught the lessons of the older agricultural areas of the East. About this time we who had been growing wheat for years took stock of our own practical situation, considering the problems as growers in the light of the data laid down by the erosion engineers.

The wheat farmer who analyzed his situation in 1920 found that after forty years of wheat growing his farm was definitely showing a lower yield, although his tillage methods had been intensified. The erosion of the hillside lands was at a progressive and alarm-

ing rate. To give accentuated proof of the seriousness of erosion the farmer had only to note the gradual increase in the loss of time associated with his harvesting. Lost time in the expensive harvesting period, as well as lower yield, were factors that no business farmer could ignore. In our own case we compared data of the early twenties with the late twenties and, although these may have been especiallly wet years from the standpoint of soil movement, we found that our daily records of 1923 gave us a harvesting acreage cut per day of about forty, while from 1927 to 1929 we were down to less than twenty-five acres per day. The equipment was comparable, the skill of the help was higher, and the conclusion was that the ditches, then six to twelve inches deep, were slowing us down and breaking up the equipment. We found our daily cost of operation for either the forty acres per day or the less than twenty-five was virtually the same, being about $80.00 per day. Our seasonal repair bill, during harvest, was slightly higher on the lower acreage, and the annual overhaul had more than doubled on the harvester in the last years of the twenties. Our conclusions pointed to this fact that ditches on our fields had caused our harvesting cost to mount from about $2.00 per acre to $4.00 in a period of less than ten years.

With this knowledge of cost, as well as decline in bushels per acre, we attacked the problem from the accounting angle. Finding we had an operating cost increase of some $2,000.00 per year on this farm and a yield which in ten years was notably below the previous average by at least 25%, it became clear that on this farm we had an opportunity to spend three or four thousand dollars if we could restore the more favorable earlier situation, before we would spend anything but the money saved.

Soil Conservation Plans Studied With View to Adoption to Our Use.

In theory, a good farmer will take no more from his soil than he puts back. The conservation engineers will be able to tell you if history records a general practice of good farming. First of all, farmers must make their business pay, or they cease to be farmers. We are not unmindful of the serious effort of Mr. W. A. Rockie, Mr. Paul C. McGrew, and others at Pullman, to find methods of erosion control which farmers could apply and yet continue to farm profitably.

It is obvious that the land cannot be taken out of production by seeding to grasses for very long unless those grasses yield a favorable return. The practical farmer has long known of permanent pasture and hay crops which made good erosion cover and built up the soil. These crops compelled livestock production in some relationship or the land had no chance to show any money income, at least for the time being. Would the soil building be so good that later the yields would offset the loss for the years in building? Would the crop man be a successful livestock man? Would prices hold until later large yields were available, and would the livestock market price stand under any large advance in the production which would accompany a general move in the Palouse Country to save the soil with permanent grass cover? Were the finances of the farmer so sound that he could wait for the soil to be rejuvenated, he might gain from this angle. Could he finance the new cost of the livestock business and wait for sales from this source? Each wheat grower has had to take these and many other factors into his erosion program. The erosion people could not give them the answer but they did make suggestions and some of the farmers made

modified applications to their particular needs.

Plan Followed on the Klemgard Farm.

Having been associated with wheat growing all my life, and having seen many profitable examples of large-scale wheat growing, I preferred to stay in this field and make my modifications by cropping methods. Livestock mixed with large-scale crop production is a heavy financial and management problem. The smaller farm is, of course, more adaptable to mixed farming.

Our problem appeared to be one of so arranging our crops that we could ignore all livestock in the plan. We must make a profit regardless of land out of use while rebuilding, and the more useful and better yielding land must produce some crop every year so that further losses from excess waterfall would be minimized. The ditches must disappear from the fields and our harvesters must go back to forty or more acres per day. There would be included in the plan a rotation which in about five years would bring profitable production from the below-par hills.

Peas, oats, barley, flax, alfalfa, sweet clover and crested wheat were tried. Formerly for years we had used a straight wheat program. Summer-fallow with wheat was the system of rotation for us then and still is a general practice in most of the region. Beginning with 1932 we applied winter wheat, spring wheat and peas to a large part of the acreage of the farm. The poorer lands were summer-fallowed. Successively thereafter all the farm land was plowed each year, except the land carrying sweet clover or alfalfa which might not be in the right year for plowing. Always there is a crop on the land and there is no bare summer-fallow on any of the 1600 acres when the winter season comes. Markets are watched for best price prospects for peas or wheat, which are virtually the only cash crops now considered. Each spring we load the acreage heavier or lighter with peas or wheat, according to price outlook. If both are low we increase the sweet clover seeding of the acreage, since no money can be made with grain, and will be back in with a heavy wheat crop three years later.

The results appear most gratifying. Although the yield per acre for wheat is lower for any one year, since wheat sometimes follows wheat, two years of successive wheat gives a somewhat larger yield than one former summer-fallow crop. For any two-year period, say wheat and peas, the combined income is usually greater than for one summer-fallow crop covering two years' use of land.

Other advantages appear to be in finding that the bushels of crops grown have increased and the gross sales income for the farm has increased over the last six years as compared with the higher price period prior to 1932 and before we had adopted this change. Diesel-powered machinery, with more economical application where all the land is cropped every year, has brought further advantage. The use of equipment has doubled but the over-all cost has not been appreciably higher. The overhead, always a large cost factor, is fairly constant regardless of the day's use. The smooth ground permits us to again cut two acres in the same period of time and at the same cost as formerly required to cut one. The legume crop is tied in with the government plan and now is almost entirely sweet clover, shifting the acreage every two years.

The dry soils drink up much water where crops are grown each summer. The water is held back on the slopes. The bottom lands are not so wet and sour in the spring and produce profitable wheat year after year. Peas are thrown in here as the market improves.

The litter of pea straw is left on the soil surface. Winter wheat is sown on this type of soil. Wheat stubble is plowed in. The dry land plus the stubble plowed in makes a non-washing surface. Wheat stubble can now be plowed in without burning the field in advance due to the constant cropping practice, establishing a much shorter straw and consequently a short, light stubble. The yield is somewhat lighter, of course, but the two-year picture is always better than one-year crops after summer-fallow.

In further conclusion, it is pointed out that the plan has worked well since 1932. The farm has been abnormally profitable during a low price period. Erosion is being controlled apparently 80 per cent as compared with the summer-fallow. Combined with the soil conservation plans of the Federal Government, the acreage left to soil building is not a total temporary loss, as it would be without this grant. Machinery application has been greatly economized and the savings in this field have largely offset all increases due to the double activity which follows cropping all the farm each year. The lower yields of wheat per acre as compared with summer-fallow do not appear to lessen the profit per acre as compared with the two-year standard. It should be noted that these systems promote the growth of weeds generally, and noxious weeds have a better chance than formerly. This factor seems to be the only drawback encountered. Attention is being focused on this problem and progress is being made. We would continue to advocate this general plan for the large-scale producer of crops in the Palouse region.

Phosphate Minerals in a Pegmatite North of Deary, Idaho

By CHARLES D. CAMPBELL
State College of Washington

A beryllium-bearing pegmatite was opened up during the summer of 1937 about ten miles north and a little east of Deary, Idaho, not far from the old mica-beryl mines. A small collection of minerals from the mine dump and new face included one striking specimen. It is a reddish-brown mass of interlocked cleavable grains, each about a sixteenth to an eighth inch in diameter. This material greatly resembles some of the apatite from Ontario. Coating the reddish mineral is a layer about an eighth-inch thick, of a deep blue color. Close examination of the specimen shows that the texture of the center mineral carries over into the blue shell which is therefore a pseudomorph after the reddish center mineral. Along the border, some grains are half blue and half yet red-brown.

The central reddish mineral is strengite, a hydrous ferric phosphate, $FePO_4 \cdot 2H_2O$, with a small amount of manganese, probably as proxy for an equivalent amount of iron. Below is a table for comparison of the optical and chemical properties of the Idaho mineral with those of the few occurrences of strengite yet described. Of the latter, the data were obtained from Winchell[1] (which see for original articles) and Brush-Penfield.[2] The data in Larsen[3] are copied from the same sources as Winchell's data.

In all the occurrences described, strengite is typically a pegmatite mineral, though its habit varies from massive to isolated crystals in cavities.

The blue coating on the strengite is the hydrous ferrous phosphate, vivianite, $Fe_3(PO_4)_2 \cdot 8H_2O$. Both optical and chemical tests confirmed this determination without question. The properties

OPTICAL AND CHEMICAL PROPERTIES OF STRENGITE

	Giessen, Germany	Giessen, Germany	Lexington, Virginia	Pala, California	General	Deary, Idaho
n_p	1.708	1.71	1.730	1.697		1.695
n_m	1.708	---.----	1.732	1.714		1.700
n_g	1.745	1.735	1.762	1.722		1.725
n_g-n_p	0.037	0.025	0.032	0.025		0.030
2V	very small	---.----	29°	medium		small
Optical character	pos.	---.----	pos.	neg.		pos.
Cleavage	Perfect (001), imperfect (100)					1 good
Chemical Prop.					Fus. 2.5 to 3	do.
					Water in CT	do.
					Ferric iron	do.
					Mn	
					Magn. after heating	do.
					PO_4	do.

of vivianite are sufficiently well known, from a study of many specimens, to demand a close correspondence for newly-reported specimens. To date, vivianite has been reported from but few places in Idaho[4] and Washington,[5] and in most of these it is found as an alteration product of fossil wood or bone. In the Gold Hill property of Idaho County, it occurs as veinlets in an altered lava. In the new occurrence, in a pegmatite cutting schists, an organic origin seems most improbable.

The third mineral, in fine-grained buff veinlets cutting the phosphates, is highly ferriferous ankerite. Comparison of its optical properties with those of the magnesium-iron dolomite series listed in Winchell[6] showed its composition to be Ca (Fe,Mg) $(CO_3)_2$, with about three times as much iron as magnesium. Wet tests confirmed this, and also showed the presence of a small quantity of manganese, a common element in ankerite.

The order of formation of the three minerals described above seems clearly to be: strengite, vivianite, ankerite. No attempt has yet been made to determine how they fit into the order of crystallization of the other minerals in the pegmatite; and it would be unprofitable to speculate, as yet, on the nature and changes of the pegmatite solutions from which they were formed. This account simply calls for attention to an uncommon mineral, strengite, a rare type of occurrence for vivianite, and an unusual pegmatite carbonate, all in one place.

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Hydrology-Snow Survey Section of the Northwest Scientific Association

REPORT BY O. W. MONSON
Montana State College, Bozeman

This section was added at the meeting of the Association December 29, 1838. It is composed of the Hydrology Section of the American Geophysical Union, North Continental Divide Area, and the Western Interstate Snow Survey Conference, who had previously met conjointly with the Engineering Section of the Northwest Scientific Association.

Dr. Joseph E. Church, Chairman of the Hydrology Section of the American Geophysical Union, and Professor H. P. Boardman, Chairman of the Western Interstate Snow Survey Conference, both from the University of Nevada, were present. Mr. O. W. Monson, Irrigation Engineer, Montana Agricultural Experiment Station, is chairman of the new Section of the Northwest Scientific Association.

Dr. Church explained briefly the purpose of the Hydrology Section and the Western Interstate Snow Survey Conference, traced the development of the new science of snow surveying, and outlined some of its possibilities.

A symposium on the topic, "The Limit of Practicable Usefulness of Snow Surveys Made in the Headwater Regions When Used for Predicting Runoff at Localities Quite Removed From the Courses," was discussed by D. B. Freeman of the U. S. Army Engineers, H. T. Gisborne of the U. S. Forest Service, and J. P. Bonner of the Soil Conservation Service.

Mr. Freeman discussed the question from the standpoint of practicable usefulness, being concerned with the prediction and control of runoff at Fort Peck Reservoir in Montana. For the operation of this reservoir it is necessary to forecast the amount of water which will need to be controlled at the reservoir each year during the flood period. As a result of the studies made to date, it appears that predictions of runoff for years in which the summer rainfall is comparatively small can be made quite accurately. In the Upper Missouri Basin the rainfall during the years 1934-37 inclusive was consistently below normal. The prediction of runoff for these years was remarkably close to the actual runoff—the greatest divergence being in 1937, when the actual runoff was 37% of normal, while the predicted runoff was 45%, a divergence of only 8%. During 1938 the actual snow depth and water content were not much different from those obtained in 1937, but the actual runoff at Fort Peck was much greater than it was in 1937 or for a considerable number of years prior to that time, and the inaccuracy of the prediction during this year was much greater than it had been during any of the dry years. The explanation is that a relatively larger amount of runoff during 1938 was a direct result of rainfall and was not a direct function of the water content of the snow blanket. For this reason, the limitation of practicable usefulness of snow surveys for localities quite removed from the course depends largely upon the extent to which correct evaluation can be made of the proportion of runoff which should be attributed to snow melt and the proportion of runoff which should be attributed to rainfall."

Mr. Gisborne approached the problem from the standpoint of watershed management. He said: "The headwaters of many streams in the North Rocky Mountains are within national forests

and the obligation and expense of protecting these headwaters from devastation by fire fall upon Region One of the U. S. Forest Service. Region One has to compete with nine other regions for its share of total fire control funds which are appropriated annually to the Forest Service for the country as a whole. No region as yet receives as much money for fire control as it believes is needed. Therefore, that forest or region whose snow courses serve as a basis for prediction of runoff or stream flow over the largest area should receive a larger proportion of fire control funds than other regions of otherwise similar fire protection problems. The principle seems already recognized that those snow courses useful in predicting stream flow of the most used or the most dangerous streams are most worth installation and operation."

Mr. Bonner discussed the problem from the standpoint of the soil conservationist. Here the problem is to have information, not only as to the amount, but also as to the rate of runoff caused by rains or melting snows. He said: "Because of the urgent need for information not only as to amount, but also as to rate of runoff caused by melting snows or by rains of varying intensities, it appears desirable to modify the existing snow survey program to include areas of lower elevation which bear no relation to the information obtained in the headwater regions. Snow courses have been located at various points in the states of Idaho, Washington and Oregon to secure information which would not be available from the courses in remote areas. The procedure to be employed follows the same general pattern of the work in higher elevations, with the exception that these courses will have to be run at more frequent intervals, so that for each period of runoff the quantity of moisture in the form of snow is available."

The afternoon session consisted of a symposium on the subject, "The Effect of Soil Priming by Fall Precipitation on Spring Runoff." This topic was discussed by James C. Warr of the U. S. Bureau of Agricultural Engineering, O. W. Monson of the Montana Agricultural Experiment Station, and a paper by Henry C. Eagle of the U. S. Geological Survey was read by Mr. L. T. Jessup.

Mr. Marr introduced the subject by explaining that "various procedures are required for different watersheds in order to successfully correlate snow survey data with runoff, and various factors, in addition to the principal one, namely the amount of water held in storage by snow cover on the watershed, must be considered. Among these is the soil priming influence of fall precipitation."

Mr. Marr's analysis to determine the influence of watershed priming was made by four tests applied to the Jackson Lake watershed in Wyoming. The first test showed the relationship which exists between snow cover and runoff without any correction for watershed priming. In the second test the fall precipitation which occurred before the snow begins to accumulate was added to the water content of the accumulated snowfall. In test number three, spring instead of fall precipitation is added. In test number four, both fall and spring rainfall were added to the water content of the snow. A comparison between test number one and test number two showed that for some years the correlation was much closer when the precipitation at Moran during October was added to the maximum water content. The best example of this was the year 1925, but when this same correction was applied for the year 1936, however, the correlation was not improved.

The net result of the four tests was that the maximum error without any

correction for watershed priming of 205,000 acre feet was reduced to 135,000 acre feet when the October precipitation was added to the water content in the snow cover, and still further reduced to 105,000 acre feet when both the fall and the spring precipitation were added to the water content of snow cover. Thus, it is seen that the factor of watershed priming must be given consideration in forecasting the runoff from a watershed and that fall and spring rainfall on the watershed may serve as fairly reliable correction factors.

Mr. Monson stated that "the water content of the snow cover, while perhaps the most important, is only one of several factors which affect the amount of runoff from a given watershed. Other factors are: (1) Precipitation on the watershed during the runoff perior; (2) evaporation losses from the watershed; (3) ground storage; (4) deep percolation losses. The engineer is faced with the problem of making corrections for these factors, although but very little basic information is available.

"The factor of ground storage or watershed priming was considered in two ways: (1) Fall precipitation as a measure of watershed priming; (2) low water flow as an index to general ground water conditions. These two tests were applied to the Snake River Basin above Moran, based on the Jackson Lake snow surveys, and to Swift Current Creek at Many Glaciers, based upon the Swift Current snow surveys. The correlation coefficient was used as the measure of influence for each of the correcting factors. It was found that the correlation between water content of snow cover and the runoff from Snake River at Moran was increased from .81 to .84 when the previous October precipitation was added to the water content. When ten times the October runoff expressed in inches was added to the water content, the correlation was increased to .88. On the Swift Current Creek watershed, the correlation between water content and runoff was .85. This was not improved by correcting for fall precipitation nor for the October runoff. Thus, it appears that in the case of runoff of the Snake River at Moran, correction by adding the previous October precipitation to the water content of snow cover on Jackson Lake watershed gave a higher coefficient of correlation than when no correction was made, but on the Swift Current watershed the factor of precipitation during the runoff season disturbed the relationship between water content of snow cover and runoff to a greater degree than could be accounted for by watershed priming." Curves and tables were submitted to support the discustion.

Mr. Eagle used the precipitation and stream flow records in the Upper Yellowstone Basin as the basis for a study.

Quoting from his paper: "The spring runoff for the Yellowstone River at Corwin Springs was compared with the precipitation at Yellowstone Park, Wyoming. The period of spring runoff chosen was from May 1 to July 31. Precipitation for the period November 1 to April 30 was considered winter precipitation. Various methods were tried to correct for ground storage. First the minimum flows for October and April were selected, but the results were unsatisfactory. The minimum flow seemed to be subject to influences such as abnormal cold spells, making it a poor index of the ground water level, and the mean flow for October was finally used in the computations. After it was converted into inches of runoff this was multiplied by three, since the period of spring runoff is three months. It was found that the correlation was slightly improved, by this method, over those for which no correlation for ground storage was made. An inspec-

tion of the amount of correction obtained showed that for most years a larger correction was needed. Therefore, instead of multiplying the October runoff in inches by three, it was multiplied by six. This method seemed to improve the correlation over those of either of the previous methods.

"In conclusion, the results indicate that there is a relationship between October runoff and that of the following spring. More representative precipitation records including snow surveys would probably give more satisfactory predictions of spring runoff."

Mr. R. A. Work gave an interesting discussion, illustrated by slides, on the construction of shelter cabins. He emphasized the importance of sturdy construction to withstand snow load in areas where deep snows occur. A novel feature to shelter cabin design is a Santa Claus chimney extending 10 to 12 feet above the ridge of the cabin through which the snow survey party may enter the cabin. Wood, food, and bedding are cached in the cabin during the fall. Salient points to be considered in locating and constructing shelter cabins for winter use by snow surveyors in isolated mountainout regions were outlined. Detailed plans of three types of cabins were shown, and some actual cost figures were submitted.

Mr. Marr described the preparation of a snow surveyor's manual now ready for publication. It contains specific information pertaining to snow surveys, including the laying out of snow courses, the taking of measurements, and a short section on first aid.

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Planting for Topographic Control on the Warrenton, Oregon Coastal Dune Area

W. T. McLAUGHLIN
Assistant Range Examiner, Soil Sonservation Service

INTRODUCTION

Sand dunes are more common and extensive in the United States than is generally realized. They occur on both coasts, in the region of Lake Michigan and elsewhere inland. Coastal dunes in the state of Oregon alone embrace at least 30,000 acres. Picturesque as dunes are they constitute an expensive menace to private property, resort property, and military lands. They threaten municipal water supplies, form menacing deposits in coastal harbors and waterways and make maintenance of highways and railroads very costly. In addition, they may override and destroy timberlands and valuable agricultural lands, rendering the latter sterile and unfit for use.

THE WARRENTON PROJECT

A characteristic dune area extends from the mouth of the Columbia River southward about sixteen miles, nearly to the rocky promontory known as Tillamook Head. Here sand from the beach combining with sand from the back areas where the protective vegetative cover has been destroyed, three years ago was threatening to inundate the military preserves at Fort Stevens at the mouth of the Columbia River and Camp Clatsop, farther south. The latter is an encampment of the Oregon National Guard on which approximately $1,000,000 has been expended. Moreover, lakes adjacent to the coast, lying on wildfowl migratory routes, and natural havens for these wildfowl were rapidly disappearing beneath the blanket of sifting sand. Sitka spruce forests, fringing Clatsop Plains on the east, were succumbing as the sand moved slowly in upon them. Here and there a few bricks and scattered boards marked the locations of former houses that had literally "gone with the wind." Hundreds of acres of rich pasture lands were reduced to barrens of shifting sand and several thousand additional acres were endangered.

In 1935 the Soil Conservation Service of the United States Department of Agriculture, cooperating with the Civilian Conservation Corps, undertook the task of stabilizing approximately 3,000 acres of shifting sand dunes and barrens, with the objective of protecting several thousand acres of land to the eastward and property valued at $10,000,000.

In control work a number of native and introduced plants of demonstrated value as sand stabilizers were available. Among these were American dunegrass *(Elymus mollis)*, Seashore bluegrass *(Poa macrantha)*, Yellow sand verbena *(Abronia latifolia)*, Bigheaded sedge *(Carex macrocephala)*, and pre-eminent among them, the European Holland grass *(Ammophila arenaria)*. The value of Holland grass has already been demonstrated in Europe and in this country.

By dividing and transplanting Holland grass into hills 18 inches apart each way it is possible to establish an initial planting that, in two years, will transform an unvegetated, shifting sand plain into a knee-high "sea of grass." But control was not so simple a matter. It was not merely a question of planting Holland grass everywhere. As the work progressed it has become evident that permanent sand dune control work involves highly complex problems and must take cognizance of land use, vegetative succession, soil and climatic factors, normal geological processes, physiographic forms and drainages.

It is not within the scope of this paper

MAY 25 1939

to consider all of the problems that have developed since the initiation of the Warrenton project, but rather to point out some less evident but nonetheless highly important aspects.

The Warrenton project may be divided north and south into two parts on the basis of physiographic characteristics and control problems involved. The northern half, except for the back area, is a sand plain of very recent formation; the southern half is a mature topography that has been largely destroyed by blowing and inland movement of the sand.

CONTROL PROBLEMS ON THE SOUTHERN HALF OF THE PROJECT

Extending from the beach eastward to the foot of the hills, with an average width of one and a half miles, the coastal flat again may be divided into three zones based on topography, vegetative cover and degree of sand stability. From the beach eastward for a half mile lies an area that consists of a complex of shifting sand, innumerable hummocks covered and protected by a capping of dense vegetation, and many low undrained pockets. On the east this area is bordered by a long, narrow lake (Neacoxie), that drains southward into the Necanicum River near Gearhart. East of Lake Neacoxie is a heavily sodded expanse characterized by a remarkable series of parallel, stabilized dune ridges and troughs. These ridges have a maximum height of about thirty feet. They are not only parallel to one another but also the coast line and follow it for miles in a great sweeping arc. The present troughs drain north into the Columbia River and southward into the Necanicum. Between the sodded flat and the hills a third zone, a continuation of the dune ridge topography but covered with a Red alder-Sitka spruce forest. It is the first or westernmost zone with its shifting sand and scanty vegetation with which the control work was especially concerned.

It was soon discovered the irregular topography with its lack of definite drainages and numerous hummocks presented a difficult problem. Every eminence causes eddying effects of the wind, intensifying the tendency to scour and makes it extremely difficult to establish a protective Holland grass cover. Many of the early plantings were locally scoured out or overwhelmed with excessive deposits of sand. The tendency to scour appeared to be fully as marked a half mile inland as a few hundred feet back from the beach.

NATURE OF THE ORIGINAL TOPOGRAPHY AND VEGETATIVE COVER

To fully understand the ramifications of this problem and its solution it is necessary to determine the nature of the original topography and vegetative cover. Armed with this knowledge it should be possible to work hand in hand with nature and help her to reestablish a safe, stable cover of sand binding plants. From Sunset Beach southward, extending parallel to the beach at a point some distance above high tide line, there remains a series of dune remnants some of which attain a height of seventy feet (Fig. 1). It is evident from their position and from the relatively advanced nature of the vegetation that these are remnants of a great foredune that extended for miles parallel to the beach and a short distance behind it. It is known that sheep, horses, and beef cattle all grazed this area since its settlement. Trailing repeatedly across the dunes, the stock cut through the protective cover and deep into the sand beneath. From these small beginnings gaps, scoured by the wind, widened and rapidly extended north and south (Fig. 2). Millions of tons of sand blew eastward, even to the edge of Neacoxie Creek, pushed the

creek out of its original course and obliterated the drainage line that extended north and south parallel to Neacoxie Creek and between the foredune and secondary dune. It is estimated that from this original foredune, extending about sixteen miles from Fort Stevens to Gearhart, approximately forty million cubic yards of sand blew landward. It would have taken 16,000,000 truck loads of two and a half cubic yards each to move this volume, or a string of trucks, end to end, extending more than twice around the earth.

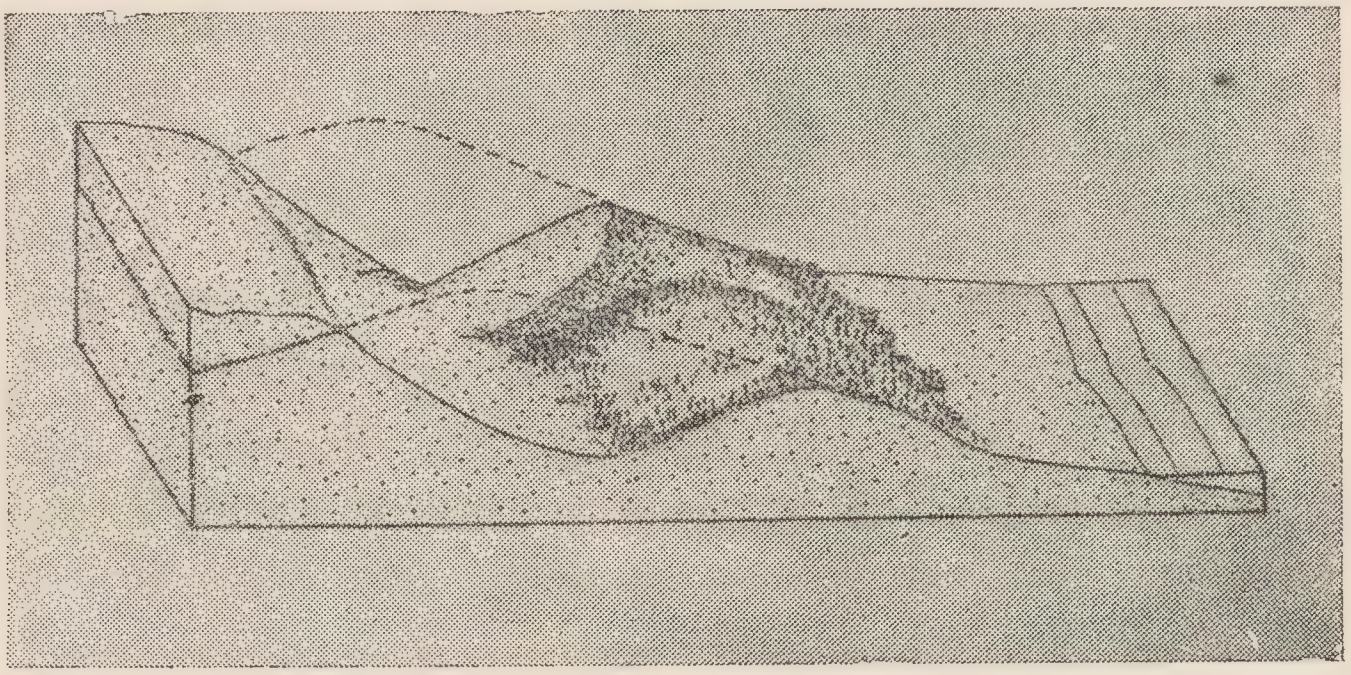


Fig. 1. The original foredune, 70 feet high, has blown inland. Occasional hummock remnants still partially block the present trough. A new foredune is building. The "black sand" layer in back areas represents the original land surface.

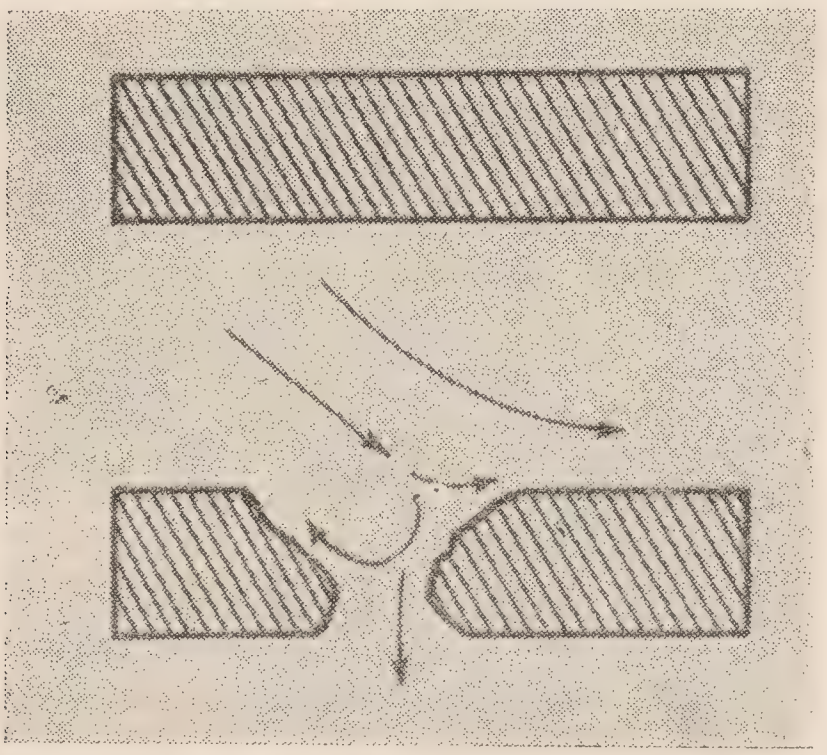


Fig. 2. A gap in the dune ridges aggravates the tendency to scour and enables the wind and sand to penetrate to the back areas.

Hansen Lake, south of Sunset Beach, and Kyle Lake, north of Delaura Beach, remain as vestiges of this drainage. Another remnant is the slough known as the Alders that extends from the vicinity of Hammond Beach northward. Willows that formerly grew along the margins of this watercourse have become covered with sand but rooted along the branches and have continued to grow upward until they now form a double line of hummocks that mark the margins of this former drainage quite as well as though it were still there (Fig. 3). From these lines of evidence, it is clear the same pattern of parallel dune ridges and troughs existed here that still persist east of Neacoxie Lake.

The significance of this fact lies in the part these ridges and troughs played in the protection of the area. There is a distinct seasonal shift in the difection of the prevailing winds (Fig. 4). During the summer it is northwesterly. At this time the sand is dry and, driven by the moderately strong winds, moves from the beach toward the southeast; that is, southward and **inland.** While the foredune and secondary dune remained these surface winds were diverted to a southerly direction, parallel to the topography, and the sand was

caught by the vegetation of the foredune.

In winter the stormy southwesterlies, often attaining high velocity, move quantities of sand, even though wet, toward the north and east. Again the dune-ridge topography diverted the wind, stopped the beach sand at the foredune and protected the back areas.

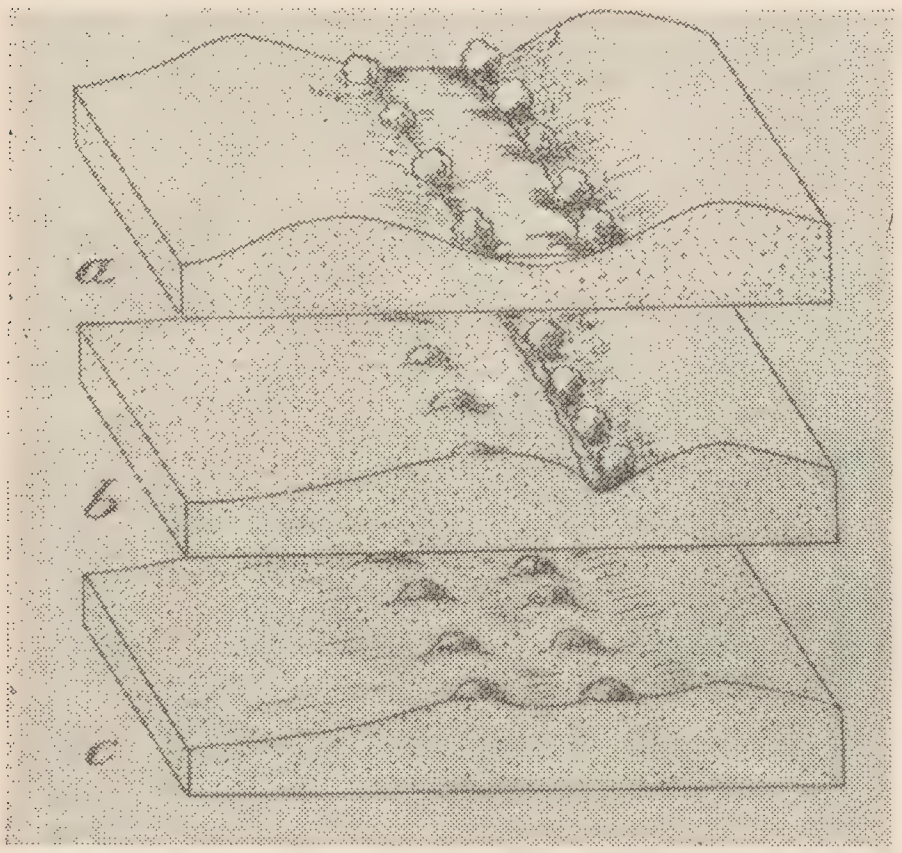


Fig. 3. Hooker's Willow is common along drainages. Where the troughs have become covered by sand the willows root along the branches, collect sand and form hummocks.

NATURAL DUNE BUILDING

BUILDING PROCESSES

Fortunately the Soil Conservation Service is not faced with the task of reconstructing a foredune on the southern part of the project. The natural dune building processes are already building a foredune to replace the one that has been destroyed. This process has been going on for a long while (Fig. 5).

Sand from the Columbia River is distributed north and south by the coastwise currents, and washed onto the beach, building it slowly oceanward. During the winter months especially, this beach sand is blown onto the foredune where it is caught by the American dunegrass and other pioneer vegetation. This builds up the foredune with an annual deposit of six inches or more. Each spring the vegetation miraculously grows up through the sand. Not content with this performance, the dunegrass and the recently intriduced Holland grass, by means underground rhizomes, extend forward onto the beach to the vicinity of the high tide line. These clumps of grass, presenting a front parallel to the beach, catch sand and quickly form a line of hummocks. This ridge now catches the sand, builds larger and thus robs the old foredune which has now become stable and occupied by a somewhat more advanced type of vegetation. It is evident this foredune building can continue only as long as the beach is building oceanward and there is a supply of sand. This condition prevails at the present time in the vicinity of the Warrenton project. Already there has been built up a foredune 300 feet wide and twenty feet high that is adequately stopping the movement of beach sand inland. The problem is not one of stop-

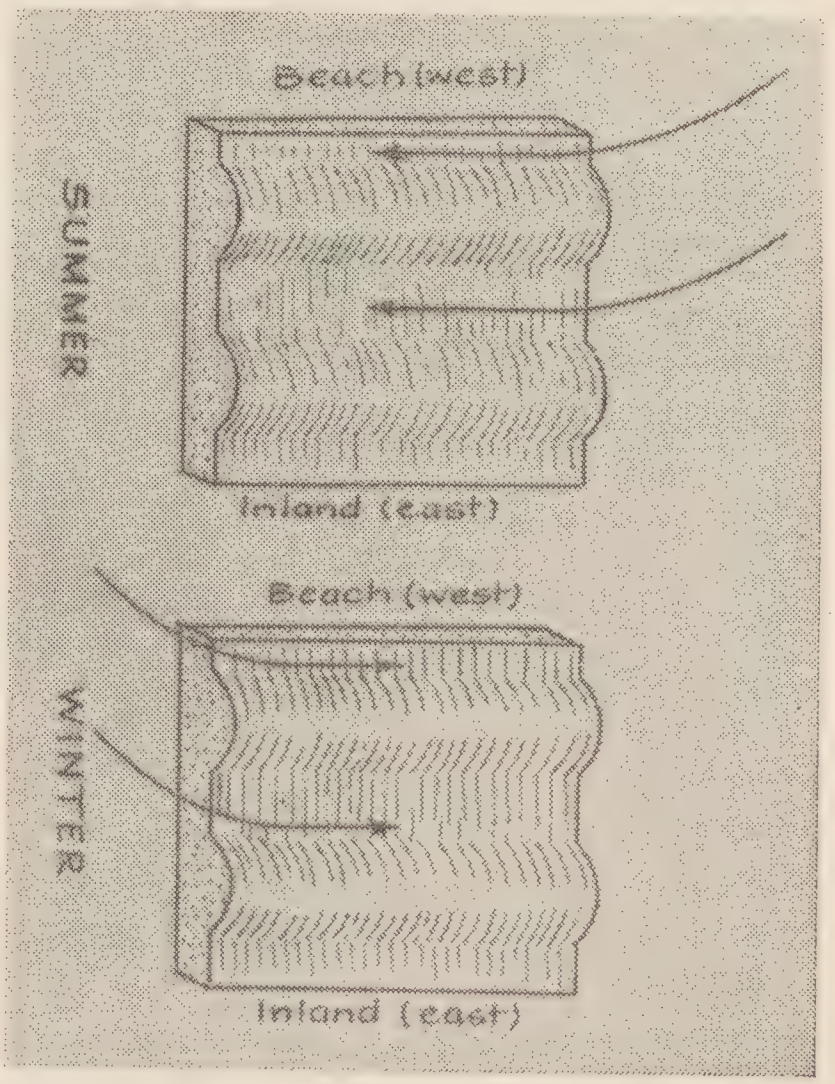


Fig. 4. Divergent effect of dune-trough topography parallel to beach in the protection of back areas from wind and from sand.

ping beach sand from moving inland, but rather one of re-establishing a safe vegetative cover and of attempting to iron out topographic irregularities. It would be highly desirable to reconstruct a parallel dune-ridge topography to divert the wind and shelter the back areas.

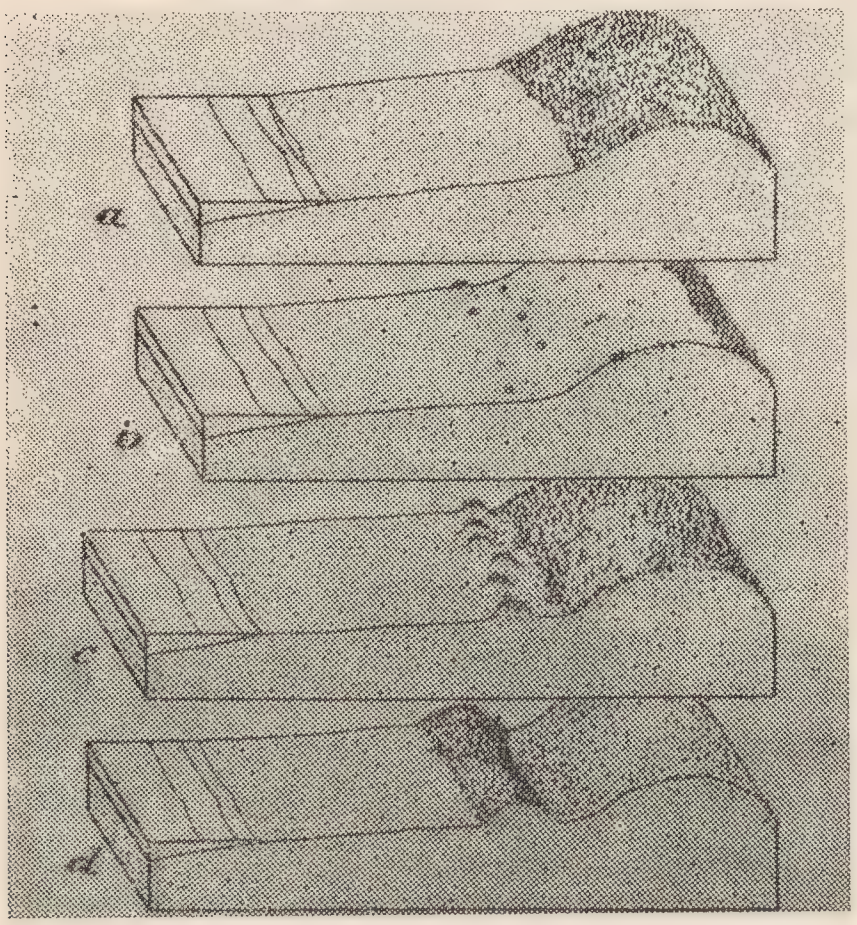


Fig. 5. The foredune ridge receives an annual deposit of sand during the winter season. The vegetation during the spring and early summer grows up through the sand cover. Pioneer species, extending onto the beach, collect sand, building up hummocks that eventually coalesce to form a new foredune as the beach line builds oceanward.

SOLUTION OF THE CONTROL PROBLEMS IN THE SOUTHERN HALF OF THE PROJECT

In the three years the Soil Conservation Service has been on the project, most of the unstable area south of Sunset Beach has been treated with an initial planting of Holland grass. This treatment will be completed and the area seeded to secondary species that will supplement the Holland grass in the development of a uniform vegetative cover. Where hummocks can be removed at little cost this is done by destroying the vegetation and allowing the wind to complete the levelling process. This is very important, as any irregularity can intensify the tendency to scour. It would be desirable to reconstruct the secondary ridge as the foredune is being reconstructed, but, unfortunately, it is no longer possible to do this except at prohibitive expense. Sand is no longer moving inland in sufficient quantity. The next best solution appears to be tying together the old ridge remnants by a planting of trees and shrubs. It is believed these broad north-south bands will add sufficient height to divert the winds as the dune ridge did formerly. Gaps, even in ridges east of Lake Neacoxie, can be plugged with woody plantings and thus spared the fate of the foredune where scouring in such gaps ended in almost complete destruction (Fig. 6). Based on evidence from woody plants growing at present on the area, it is believed these plantings will conform to the ridge contours by wind distortion and so fill the gaps more permanently than any mechanical structure could do.

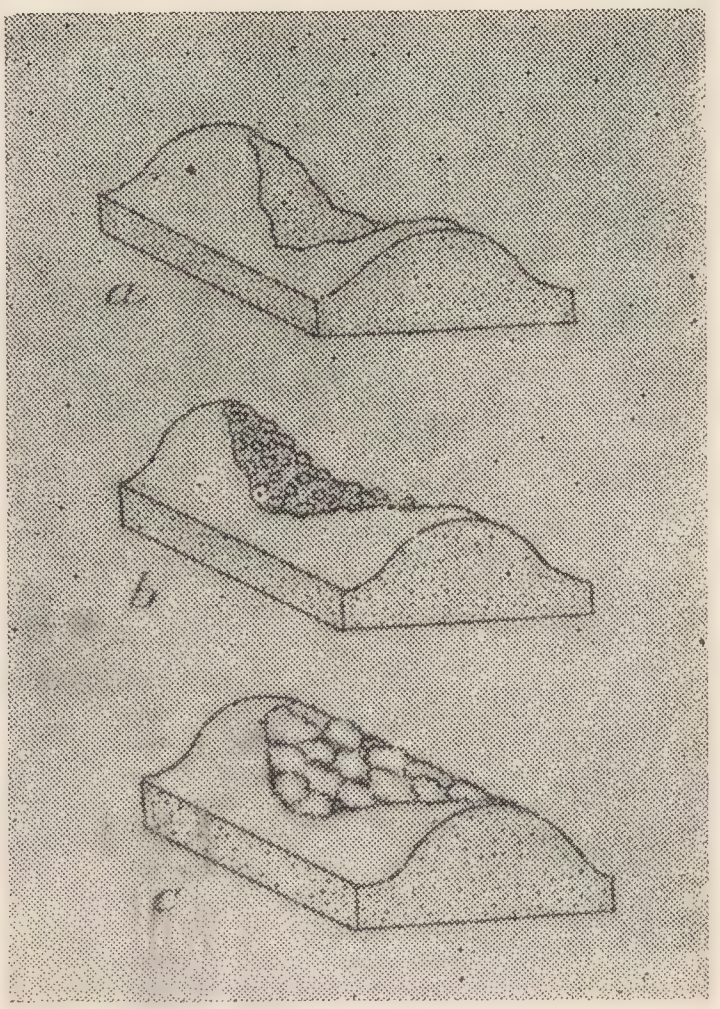


Fig. 6. Woody plantings placed in dune wind gaps are expected to fill the gaps and so to re-establish the uniformity of the dune contours.

DUNE BUILDING ON THE NORTHERN END OF THE WARRENTON PROJECT

The northern end of the Warrenton project area presents a quite different problem. Because of its proximity to the south jetty, extended 1905-1936 to a total of seven miles at a cost of $7,618,-000 to provide a channel adequate to commerce at the mouth of the Columbia River, this beach line has built oceanward by the deposition of millions of cubic yards of sand. Since 1856 a low lying flat a half mile wide has been deposited. This outward extension has been so rapid that vegetation has been unable to keep pace with it and the normal dune building processes, functioning at the southern end, were outstripped.

Three years ago storm tides broke over this flat, extending inland to the edge of the old high dunes, and deposited quantities of drift wood. This great expanse of unvegetated sand was the source of supply for small dunes that were moving inland, engulfing the old drainages, covering timber and threatening military lands and recreational areas.

The flat expanse is broken by occasional Holland grass hummocks, but the seaward extension of the beach line here progressed too rapidly for these hummocks to coalesce into a continuous dune ridge. It is now necessary to go back and, by the use of picket fences and Holland grass plantings, to build up the dune ridges that did not build naturally.

In order to protect the flat from storm tides, and, as the initial step in control of this part of the project, two lines of picket fences were driven thirty feet apart and parallel. These extended for eight miles, parallel to the ocean beach at a point somewhat above the high tide line. The pickets were placed from November, 1935, to the summer of 1936 and were subsequently raised twice. The last time, during the summer of 1937, care was taken to maintain a horizontal top line. In the fore part of the 1937-1938 planting season the ocean side of the artificial foredune was planted to Holland grass in a strip fifty feet wide. Later in the season the eastern slope was similarly planted and the crest between the two lines of pickets was planted to American dunegrass. The dune ridge is now approximately eight feet above the original sand level (somewhat lower toward the south), with a base 130 feet wide, and forms an effective barrier to the sea and to the sand moving inland from the beach.

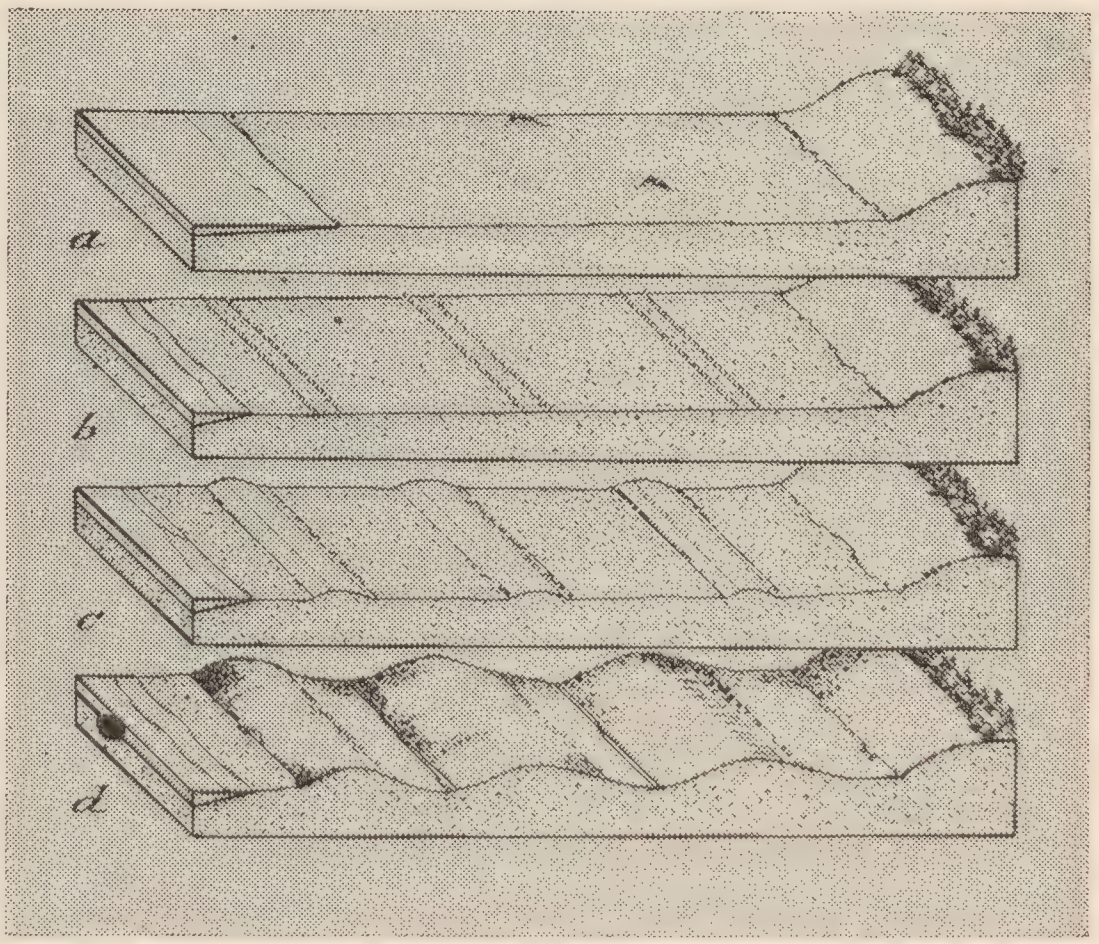


Fig. 7. Parallel picket fences catch sand and build up dune ridges sufficiently so they may be planted with Holland Grass. Intervening areas, wet in the winter but dry in the summer, scour, and the sand, depositing in the planted strips, builds the dune ridges higher.

It has been found that heavy grass plantings alone caused the deposition of sand moving into them and so resulted in dune-ridge development. Thus, by making a series of plantings one to two hundred feet wide separated from one another by wide unplanted gaps, a series of dunes and troughs can be ini-

tiated. In this construction the wind does the actual work of transportation and in its scouring and deposition is directed by the location of the plantings. The unplanted gaps are essential since the sand scoured from them deposits in the grass planting to the eastward. In time there will result a stabilized condition because the troughs will scour down to the permanent water table and then scouring will cease. The low areas adjacent to the water will become occupied by a hydrophytic dune community.

Because of the presence of standing water up to three feet in depth during the rainy season, which coincides with the planting season, it has been difficult to complete the Holland grass planting on the flat. In order to build up a portion of the flat so the grass strips can be planted, two additional double-row sand fences have been constructed. The second fence is parallel to the foredune and 800 feet farther west. A 600 foot gap intervenes between the second and third fences. It is expected these two back fences will have collected sufficient sand by next (1939-1940) planting season so the grass strips may be planted.

It has been found that a Holland grass planting, by the end of the second growing season, will be well established so there is practically no sand movement within it. Of course sand may deposit from an adjacent unplanted area. In order to insure a more complete and stable cover, seeding of certain native grasses and legumes in the stabilized Holland grass plantings is being practised.

The broad, strip-gap system of planting Holland Grass appears to have certain distinct advantages over a solid planting. Complete stabilization of a flat sand area is believed possible with a fifty per cent or more reduction in planted acreage and consequent reduction in cost. By placing the grass in broad bands parallel to the beach a series of dune ridges is built. These ridges tend to divert surface winds and protect back areas from beach sand. A parallel drainage pattern, normal for dune topography, is established. It is apparent this type of planting with the resultant topography is in agreement with the natural trend and consequently assuming protection from destructive agencies, constitutes a permanent dune stabilization program.

Contributions to the Ecology of the Big Bend Area of Washington

Forage Resources of the Scabland Prairies and the Effects of Grazing Upon Them.

REXFORD F. DAUBENMIRE, University of Idaho

For the past few years we have been interested spectators of a major land development project here in the Northwest, the Grand Coulee Dam. We are told that when this gigantic structure is put into operation a region which is now a sparsely populated desert will be turned into fertile agricultural land which will support a great many more people.

With the farms limited to 40 acres per person, as now planned for the region to be irrigated, correct utilization of each tract will be necessary if the owner is to make a living off his land. The desert vegetation in this area is not uniform in composition, and since these plant communities are the result of centuries of adjustment to climate and soil, we may wel lexpect fundamental diversity in the soils occupied by each vegetation type. Studies elsewhere in the arid and semiarid portions of the United States have shown that the original vegetation types provide the most reliable indicator of crop potentialities (Kearney, 1914; Kelley, 1922; Shantz, 1911; Shantz and Piemeisel, 1924). Such studies have never been made in Washington, nor are the specific results of the studies made elsewhere applicable here.

The development of the Washington irrigation project, in contrast to the misguided history of the "dust bowl" of the Middle West, promises to follow a course dictated by the findings of scientific research. These findings must be the synthetic product of specialists: ecologists, soil scientists, agronomists, engineers, etc.

The first type of research needed of the ecologist consists of a definition of the vegetation types, and a study of their dynamic interrelationships and general ecology. Such a study will be significant only if based on a larger area than the irrigated lands alone; it should include the entire Big Bend country. The writer has begun this preliminary study, and has gained considerable data along this line.

A second phase which follows logically in order will be a series of soil investigations by either the ecologist or the soil scientist. When we have determined the range of soil conditions which each plant-cover type indicates, we will have a guide to the crop potentialities of the various regions, and to the type of management which will maintain the soils in their most productive states.

We must extend the horizon of research to include the region surrounding the irrigated lands, for readjustments must also be expected here. For example, as irrigation removes a large part of the desert from its present use as range land, new pressure will fall on the surrounding pasture lands. Outside of the desert there are extensive areas of scablands which can never be used for wheat or for irrigated agriculture, and over much of their extent they will produce considerable forage if handled properly.

Today these scablands are in a sorry condition. So badly have they been overgrazed that no one knows just how much forage such lands are capable of producing under less injurious treatment. The effect of grazing upon the various species, and the inflence of grazing systems upon the vegetation types are matters of unquestionable significance. Studies of these problems have been under way, and sufficient

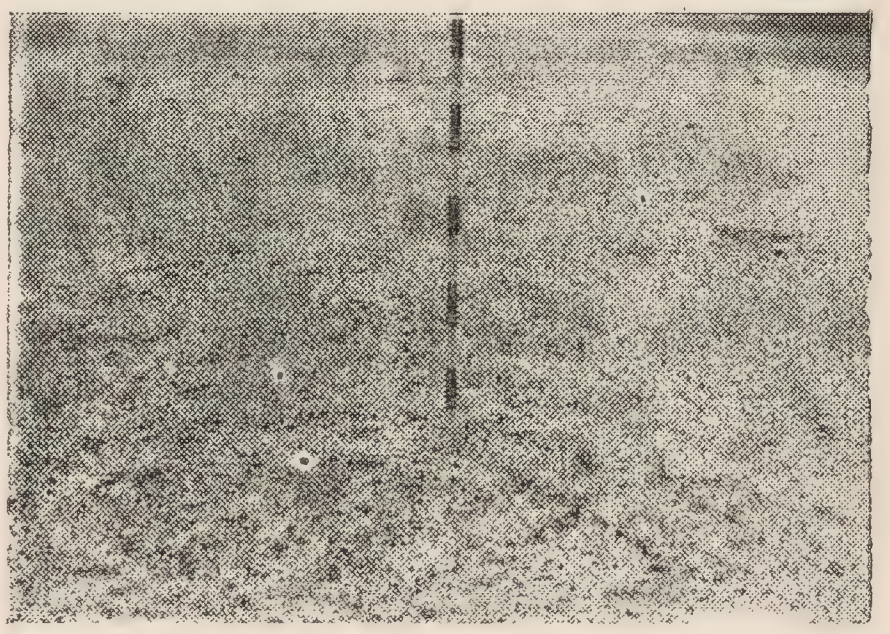
progress has been made to warrant a preliminary report on the composition of the virgin scabland prairie, and the effects of grazing upon it.

Although remnants of virgin prairie in the scablands of Washington are exceedingly difficult to find today, considerable search has brought to light one such area in Franklin County which is in excellent condition. In the vicinity of this stand there also occur pastures which have been subjected to varying intensities of heavy grazing, and which consequently exhibit several degrees of retrogression. When all these areas are lined up in the proper sequence they give a picture of the vegetational changes brought about by overgrazing, and also show the response of each species to the grazing factor.

In order to grasp the significance of the changes which accompany grazing, it is desirable to know the relative amount of forage produced each year by the various species of the virgin prairie. By clipping each species at the ground line at the time of its maximum seasonal development, the amount of oven-dry matter produced each year has been determined (Table 1.). From this table it is apparent that wheatgrass contributes about 85% of the forage, with bluegrass and cheatgrass contributing about 5% each.

Station 1. An area which was lightly grazed prior to 1911, and which is apparently typical of the association in virgin condition. The dominant Agropyron bunches contribute 85% of the annual forage output in this community, with the smaller interstitial plants of Bromus and Poa each contributing 5%.

Station 2. Heavy grazing has eliminated the smallest Agropyron bunches and reduced the size of those remaining. The ground is developing a cover of small plants, some of which are annuals and some perennials. The stake is marked off into decimeter units.



Station 3. Agropyron bunches are eaten back to the ground line so that the short weak shoots which are put forth each year can be distinguished on y with close study.

A statistical comparison of three grazed and one virgin areas of grassland was made by the frequency method. In each of the four areas studied a station consisting of 100 frequency plots was laid out. The plots were 2 x 5 dm. in dimensions, and were arranged in five parallel rows one meter apart. Each plot of the 400 was studied at three critical dates (April 7 or 8, April 30 or May 1, and May 21 or 22) which were so timed that the entire vascular flora (part of which is very ephemeral) could be studied.

TABLE 1.
OVEN-DRY WEIGHT OF FORAGE PRODUCED BY VEGETATION IN POUNDS PER ACRE

Agropyron spicatum	6 749
Poa secunda	388
Bromus tectorum	367
Brodiaea douglassii	102
Antennaria dimorpha	76
Astragalus spauldingii	67
Lithospermum ruderale	33
Plagiobothrys tenellus	14
Achillea lanulosa	11
Plantago purshii	10
Festuca pacifica	6
Erodium cicutarium	6
Sisymbrium longipedicellatum	4
Agoseris glauca	3
Calochortus macrocarpa	3
Madia exigua	1
Total	7,840

Station 4. Agropyron is completely eliminated here but the soil is fairly well covered with a community of small unpalatable species which is dominated by the perennial Poa and a group of annual dicots. Apparently a biotic climax. All four pictures were taken on May 21, 1938.

The results of this study are contained in Table 2. According to their responses to the grazing factor, the tabulations show that the plants may be divided into four groups.

Group one includes those species which decrease in frequency as the intensity of grazing increases. This decrease in some if not most cases seems directly due to stock eating the aerial shoots. In perennials, such as Agropyron, the underground organs become weakened due to undernourishment caused by the repeated removal of photosynthetic tissue, and the decline in vigor of such plants is gradual until the plant succumbs. With an annual which is grazed, such as Bromus, the first few years during which the stock feed on the plants so heavily that no seeds are matured spell a rather sudden extinction of these plants from the range.

It is significant from the point of range management that 90%, by dry weight, of the total output of shoots in this Agropyron bunchgrass association is produced by two members of this group of species: Agropyron 85%, and Bromus 5%. The amount of this forage available in the extremely overgrazed range is negligible.

A second group of plants includes a few which seem to be favored by grazing. These plants for the most part are not palatable (except for the basal leaves of Lepidium and Agoseris and small amounts of the young shoots of Cryptanthe), are not seriously injured by trampling, and their shoots can withstand exposure to the full force of drying winds and intense insolation. Apparently these species are kept out of the virgin prairie by competition afforded by the dominants of that community. Most of the plants in this group are small annuals, and members of the borage family are conspicuous among them.

A third group of species is made up of plants which are immediately benefitted by the removal of the competitive influence of the original dominants, but which are not very well adapted to the biotic and aerial factors which accompany the final stages of range deterioration.

The fourth and last category is an assemblage of hardy unpalatable plants whose abundance seems scarcely increased or reduced by the radical changes in environment which are brought about by intense grazing. All were present in the virgin prairie, have

persisted through the period of deterioration, and are among the relatively undesirable species which domi-nte the overgrazed range.

From the foregoing it is evident that due to the influence of heavy grazing, plant succession leads from the virgin prairie, a wheatgrass-bluegrass-cheatgrass association, to an association dominated by bluegrass and small, annual, dicotyledonous plants. Since Agropyron and Bromus together form 90% of the virgin prairie, any plan of range management which maintains the vegetation in a condition most nearly approximating the virgin state would be most desirable.

Some significant information on this point has been derived from observations of a station in central Whitman County. Here there is a good remnant of near-virgin prairie between the fence and the roadside. Within the fence livestock are permitted to graze in fall and winter, but not in spring and summer. During the growing season, the prairie within the fence assumes an aspect very similar to that outside the fence, and although the cured shoots are eaten to the ground each winter, this system of grazing seems to have very little detrimental effect upon the native prairie whereas spring-fall grazing reduces the forage production tremendously. A desirable grazing system would therefore emphasize fall or winter utilization of cured shoots and minimize spring use of the range.

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TABLE 2. FREQUENCY OF PLANTS AS AFFECTED BY GRAZING

Behavior under influence of heavy grazing	SPECIES	FREQUENCY OF OCCURRENCE Climatic Climax	Early Retrogr.	Late Retrogr.	Biotic Climax	Annual (aa) or Perennial (p)
Decreasing in Frequency	*Agropyron spicatum* (Pursh) Scribn. & Smith*	70%	53	22	+**	p
	Bromus tectorum L.	100	3	31	2	aa
	Epilobium paniculatum Nutt.	58	17	4		aa
	Agoseris heterophylla (Nutt.) Greene	16	9	9	10	p
	Achillea lanulosa Nutt.	6	3	+	+	p
	Calochortus macrocarpus Dougl.	4				p
	Cogswellia macrocarpa var. *artemisiarum* (Piper) St. J.	3	6			p
	Astragalus spauldingii Gray	2			+	p
	Erodium cicutarium (L.) L'Her.	1	+	+		aa
	Gilia gracilis Hook.	1				aa
	Lagophylla ramosissima Nutt.	1				aa
	Festuca idahoensis Elmer	+	+			p
	Cogswellia triternata (Pursh) M. E. Jones	+	+	1		p
	Sisymbrium longipedicellatum Fourn.	1				aa
	Lithospermum ruderale Dougl.	+				p
	Delphinium nelsoni Greene		2	+		p
Increasing in Frequency	*Plantago purshii* Nutt.	84	100	100	100	aa
	Plagiobothrys tenellus (Nutt.) Gray	12	2	28	100	aa
	Cryptanthe flaccida (Dougl.) Greene		53	56	100	aa
	Pectocarya penicillata (H. & A.) A. DC.				79	aa
	Lepidium densiflorum var. *elongatum* (Rydb.) Thell.				67	aa
	Lappula redowskii (Hornem.) Greene	1			32	aa
	Erigeron concinnus (H. & A.) T. & G.				30	p
	Antennaria dimorpha (Nutt.) T. & G.	+	3	2	8	p
	Agoseris glauca (Pursh) Steud.	1	+	2	6	p
	Stephanomeria paniculata Nutt.				2	aa
Characteristic of Intermediate Stages	*Lithophragma bulbifera* Rydb.	25	98	100	36	p
	Festuca pacifcia Piper	63	100	70	8	aa
	Alchemilla occidentalis Nutt.		79	69		aa
	Sisymbrium altissimum L.	+	2	61	2	aa
	Cogswellia farinosa (Geyer) M. E. Jones	+	27	2		p
	Madia exigua (Sm.) Gray		32			aa
	Ranunculus glaberrimus Hook.		1	2		p
Frequency Scarcely Affected	*Poa secunda* Presl.	99	100	100	100	p
	Draba verna L.	100	100	100	100	aa
	Brodiaea douglasii Wats.	21		66	23	p
	mosses (all Bryales)	99	100	100	100	p

*Includes A. inerme (Scribn. & Smith) Rybd. which is considered by the writer as one form of A. spicatum. All have identical ecology in our region.

**Presence in the community, although not frequent enough to have been included in one of the plots is indicated by a +.

Northwest Mineral Supplies

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The essential raw materials for the manufactured products of a nation include many types of materials of both plant and animal origin.

As to food and clothing, our Nation could, if needed, feed and clothe itself and still have available products for export. In case of war when imports might be cut off, supplies of essential minerals are of much importance. Among such essential minerals are nickel, cobalt, chrome, iron molybdenum, antimony, tin, copper, lead, manganese, magnesium, aluminum ores, chemical coals, and limestones.

Value of Mineral and Electro-Chemical Industries to the Northwest.

The electrochemical and electrometallurgical industries depend essentially upon large supplies of minerals.

Minerals in the so-called organic industries are consumed in large tonnages, often in larger amounts and of greater value than the organic raw materials themselves. Illustrations of industries which the average individual does not realize consume great quantities of minerals are the following: rayon, leather, textiles, paint and varnish, plastics, pulp and paper, soap, vegetable oil, sugar and syrup.

It is desirable to inventory the Pacific Northwest and Alaska for raw materials available for the upbuilding of a greater internal and coastwise traffic on the American continents, both North and South. The abundance of water power, the equable climate, and a growing population require that systematic development of Alaska and the West Coast be given national attention. The mineral resources of Alaska and the Pacific Northwest are enormous but practically untouched. In the past the development was left to the entrepreneur and to such large corporations that could afford to transmit western raw products to specific centers of population. No attempt has ever been made to inventory the mineral supplies with a view of upbuilding local industries and providing for employment of local labor. Such an enterprise is one beyond the scope and power of private industry and of local governments. It can only be accomplished by a National agency.

The northwestern portion of the United States is the least developed in the richest in material resources of any part of the country. In minerals, water power, forests, and fisheries, the western country is of the greatest value to all of the United States. It is sparsely populated, practically undefended, and industrially incomplete. Diversification of manufacturing is greatly needed to stimulate an equable distribution of labor and to put to national use the great water powers now being developed. Much of the labor is now seasonal and tides of unemployment come and go with the summer and winter periods.

To establish diversification of manufacturing many basic industries will have to be brought to the west coast, such as the manufacture of heavy chemicals, the electrometallurgical and electrochemical plants reducing many metallic and non-metallic products, and the fertilizer and by-product industries affecting the development of a prosperous agriculture. With these in being, the population may be expected to grow rapidly and markets will be developed for many local products.

As no systematic attempts to evaluate the reserves of the many and various natural products of the different Northwest areas has ever been made, it would appear that immediate action in

this respect is highly desirable. The future mineral development of Alaska and the Pacific Northwest cannot be left to private industry. Indications are that Alaskan copper production will be negligible within a few years, due to the closing of the famous Kennecot mine, and no comparable reserves are being opened. Shortly, the principal production will be only gold, which can be shipped long distances due to its great value compared with its small bulk. The basic minerals of Alaska still remain to be developed. Many mining districts throughout the Pacific Northwest are now dormant for the same and other cogent reasons, One of which is a smelting monopoly, or quasi-monopoly, which is only interested in supplies for its established plants. To open Alaska for settlement, which is necessary to prevent its possible conquest in the future by a foreign power, some attention to local treatment of base metal ores in the territory is necessary. Some study should be made of this problem as a necessity for adequate national defense of the west coast.

The same reasoning for some other minerals not now beneficiated applies to the Pacific Northwest, which is only sparsely inhabited, compared to its vast potentialities for settlement.

Examples of Minerals Having Industrial Importance.

Iron and Steel.

The market for iron and steel products of the type suitable for comparatively small iron fabricating plants and not including ferro-alloys, now supplied by importations, is in excess of one million tons a year. Large supplies of iron ore peculiarly adapted to electric smelting are available to the Pacific Northwest at costs comparable to those of eastern steel plants. Little attention has been given in this country to the art of electric smelting of iron ore in spite of its many potential advantages.

In addition to the American Pacific Coast market, it is a proven fact that eastern Asia is incapable of meeting its present and far from meeting its future needs in iron and steel.

It would seem advisable that the Government should study the possibilities of electric iron production in the Northwest to supply some of the market that is anticipated by the building of additional plants in the congested population centers of the East. Thus last year Bethlehem Steel decided to spend $20,000,000 in a new plant to meet the enlarging and changing market. U. S. Steel has spent even a larger sum in rebuilding.

Ferro-Alloys.

This is an age of specification ferro-metals. Announcements of intended building of new plants for the production of ferro-alloys appear frequently in the trade journals. Ferro-alloys are electric-furnace products. The raw materials for ferro-alloys are either available in the Northwest or are now being obtained from foreign sources located closer to the Northwest than the present producers. Some of the energy of federally-developed hydroelectric plants might be well used to produce ferro-alloys instead of building additional plants elsewhere.

Manganese.

Manganese is essential for the production of steel and a primary constituent in many steel alloys to which it gives toughness and other valuable properties. For many years the United States has been consuming 20 to 25 per cent of the world's manganese supply, but we have furnished from our own mines only one-half of one per cent of this supply. We import over 380,000 tons of manganese ore annually. Of this imported ore 40 per cent comes from U. S. S. R., 15 per cent from India, and the balance in scattered lots from trans-Atlantic sources.

In order that our Nation may have

iron and steel it must depend upon foreign sources for a dole of about 58,000 tons of manganese ore each month.

Manganese is preeminently a war-essential mineral, both to maintain the production of steel for general use and, especially, for the production of the implements of war. Hence, Congress has several times considered the purchase of a huge stock pile for a defensive war. It is estimated that in such a war for survival we would need to produce sixty million tons of steel which would require fourteen pounds of metallic manganese for each ton of steel.

We would be helpless before an enemy provisioned with manganese if our present supply were shut off. Hence, army experts have recommended the purchase of 700,000 tons of ferromanganese containing at least 40 per cent manganese metal.

The most attractive indication of a possible supply of manganese is in the Olympic Peninsula of Washington. This area deserves exploration and, if possible, the development of a supply of ore and a process for treatment at least to serve the Nation in time of national necessity.

Aluminum and Alumina.

Aluminum metal is produced from the aluminum oxide, alumina, and the latter can be produced from clay by various processes now in commercial use in foreign countries, and all processes require much electric energy. There are no known supplies of bauxite on the West Coast, but millions of tons of high-grade kaolin, or china clay, unexcelled anywhere in the world, and from which alumina can be extracted, are known in the Pacific Northwest. It is strictly an electrical industry. As a basis for an extensive western aeroplane industry and to supply lightweight metal for transportation and other purposes, these deposits deserve careful attention. Much experimental work should be done to render them immediately commercially available.

The kaolins known to exist are also equal in quality to any other domestic or foreign kaolin for use in ceramics and refractories, both of which are rapidly moving toward electric production methods. These china clay deposits will also afford silica sands for glass, silicon carbide, ferrosilicon for high-grade alloy steels, and much fine, white mica for molded electrical insulation and other filler purposes.

No private industry exists in the Northwest to prepare properly these kaolins for industrial use and preliminary experimental work will require Government aid. A western glass industry will require alumina for glass refractories and silica for glass mixes which can be obtained from these china clays. Other reported clays of the Pacific Northwest need investigation for industrial purposes. Heretofore, much of the high-grade kaolins have been imported from England for paper fillers and ceramic manufacture. The western product will supply all western requirements for many years to come. Aluminum ores are now imported largely from British Guiana.

The United States might well study the possibilities of being independent of foreign supplies for an essential metal like aluminum, and meet the growing demand for ceramics and refractories by using Northwest kaolins and Northwest hydroelectric energy.

Phosphorus and Fertilizer.

No one needs to review the fundamental need of phosphorus ores essential to the arts of peace and indispensable in war. Here we will consider it only a fertilizer. The southeastern corner of the United States is the only part of the Union that has phosphate erftilizers at less than a luxury cost. In a Nation deeply concerned with the agriculturist the neglect to use our great supplies of phosphates for the

benefit of the Nation as a whole is pathetic.

The Northwestern States contain 93 per cent of the **high-grade** phosphate reserves of the United States, and more than half of the world's supply.

There are proven reserves of over five billion tons in Idaho and four hundred million tons in Montana and for the world as a whole only ten billion tons.

Japan at present takes one-fourth of our total (Florida) supply, but China may be expected to use all we can produce in the Northwest in excess of our Coast demands. The estimated annual market for Northwestern phosphates is three hundred million tons a year.

The South Atlantic States use 217 pounds of phosphates to the acre, an amount that could be expected to be used on the Pacific Coast farms if the price were as low. The price for phosphate fertilizer in California has approximated for many years near $100 a ton—the average for the whole United States is $36 a ton, but for the South Atlantic States retail prices have always been below $10 a ton.

A number of large mines should be established and hydroelectric plants developed on the upper Columbia to reduce these ores and to provide deep-water shipment to the world markets.

The development of the Northwest phosphates and the preparation of them for land fertilizer is too big a job for private enterprises.

As a Government enterprise it is justified on the same grounds as other efforts to conserve soil and assist the farmers.

Magnesium.

Magnesium-bearing ores yield products for many uses; a very important one is for refractories, but its greatest future use is for the production of magnesium metal. The production of magnesia can be done in electric kilns, but the production of the metal is wholly by electric methods which consume much power.

Magnesium is the **"Metal of the Future."** Its cheap production will open up to mankind many fields of activities now denied him. Magnesium weighs only two-thirds as much as aluminum and only one-fourth as much as steel. Alloys rich in magnesium have a specific gravity of 1.83 or less and these alloys have working properties similar to steel; the corrosion resistance of some of the alloys is high, and, in addition, weight for weight some alloys are seven and one-half times as strong and stiff as steel. No other metal has such light weight and yet such great strength. It can be made into wire, ribbons, sheets, rods, beams, and intricate castings. It is indeed a **"Wonder Metal."**

The production of this metal using our undeveloped Northwest water powers and our great ore supply will contribute strictly to a non-competitive market. Thus the consumption has increased 50 per cent per year since 1922. The production of magnesium metal in the United States is absurdedly small —less than 3600 tons a year. Compare this with the predicated production this year for forty thousand tons for Germany, three thousand tons each for Austria and England, five thousand tons for Japan, and a world production of sixty thousand tons. The reason the United States production is so small is that the only present eastern producer is limited in production by inadequate local supplies.

The Northwestern States possess the largest supply of high-grade, low-cost magnesia ores in the United States. This fact combined with cheap water power and the rapidly expanding market justifies the Government in making available an ample supply of the "Metal of the Future" to our people.

Chemical Coal.

The coal of the Northwest has never received the exploitation it deserved

because of competition with low-cost petroleum. Its qualities make it a high-grade source of raw material for the electrochemical and electrometallurgical industries.

Alaska and the Northwest possess several billion tons of this coal that can be mined and laid down at low cost close to hydroelectric sites. Chemical use of this coal will require much electric energy, give vitality to many dormant and unexploited coal deposits, use a large amount of labor, and yield products obtainable now only at high cost to western consumers.

Directly the coal can be used to make graphite, silicon carbide, calcium carbide, and many hydrocarbon derivatives.

As a future study the hydrogenation of various types of coal to make synthetic gasoline is a process warranting serious study, as it has been successfully accomplished in England.

Limestone.

Some of the purest and best limestones in the world are known to exist in and tributary to the Pacific Northwest. Little use is now made of them except for cement manufacture. The limestone industry is the foundation of many heavy chemical industries which will require large quantities of electric energy. Some work has been accomplished in the evaluation of West Coast limestones, but a much more detailed study of the better quality material is desirable. It is estimated that four million tons a year will be required. This will mean the establishment of many quarries at scattered localities and afford a labor market now difficult to fill in separated and smaller communities, thus creating local supplies for nearby farms.

Alloy Metals.

Industry today and more so in the future will require specification metals possible only by electric-furnace treatments of mixtures of rare metals. There is much evidence of the presence in the Northwest area of these rare metals but no search has been made for them. In general, the industries of the United States have preferred to buy them from countries populated by cheap labor. This policy can hardly be justified in times of peace and would be fatal in times of war.

Chromite.

The metal chromium comes from the mineral chromite. The metal is a war metal, necessary for stainless and non-corrosive steels which will withstand high temperatures. It is extensively used in steels going into artillery and ordnance for military purposes. Large, but scattered, supplies of chromite ore are known throughout the Northwest and Alaska. The metal is essential for a western steel industry. The only attempt to survey the known deposits was made by the War Industries Board, but it succeeded only in getting a few mines in operation when the war closed. Now is the time to take steps to avoid the same failure again. An estimate of the known reserves is very desirable; during the last war many small chromite mines were operated, but the present state of the reserves is unknown.

By Government guidance, a number of mines could be put into operation to furnish ore from which rustless electro-steel could be made. The market for this product is increasing 30 per cent per year.

Practically all chromite is now imported from foreign countries and produced by cheap labor. At least in the one area in the United States where chromite ores occur along with undeveloped hydroelectric power, we should, as a matter of insurance, initiate such an industry.

Nickel and Cobalt.

Deposits of these minerals are reported in the Pacific Northwest and British Columbia and Alaska. Northwest nickel

concentrates are now being shipped to Japan for war purposes. No systematic attempt to correlate all information on western occurrences has been made. The metals are invaluable for high-grade steel alloys such as armor plate and for plating coatings to prevent rusting. Practically all the supplies come from Ontario in eastern Canada.

The smelting can be done, and the preparation of the alloys is always done, in electric furnaces. Studies should be made of possible deposits of nickel and cobalt minerals and methods of production in order that the country may be more independent of foreign supplies of these metals. Development of these industries in the Northwest would not compete with any United States producer; in fact, this would partake only of part of the market afforded by the 30 per cent increased consumption each year.

Molybdenum.

Occurrences of this metal are known throughout the Northwest and some development has occurred on a small scale. No attempt to evaluate the deposits has been made. The metal is used to make special steels used in naval and military construction and in trucks. tractors, and similar articles. The bulk of the United States production is obtained in Colorado and Arizona. A west coast reduction plant would be invaluable to a western steel industry. The deposits require thorough investigation to determine their ultimate value.

Tungsten.

Tungsten ores are mined and shipped east from Washington and Colorado. The element is rare and workable deposits very valuable. All areas where tungsten ores have been reported should be investigated thoroughly. It is utilized in special alloy steels for metal-cutting purposes at high temperatures and in electric light bulbs. Our supply now comes mainly from south China.

Tin.

The use of tinning sheet iron to form tin-plate for use in canning foodstuffs is well known. Practically all American supplies are derived from Bolivia or the Malay States. Alaska has valuable tin discoveries and some ore has been shipped to foreign countries for reduction. A thorough-going study of the possibilities of Alaskan production should be made and of the possibilities of the beneficiation of the ore in a West Coast plant.

Tin is also a war-essential mineral and since Bolivia could not supply all our wants except at exorbitant costs, we would be dependent upon distant trans-Pacific supplies.

The West Coast canning industries con sume 100,000 tons of sheet tin a year.

Antimony.

Deposits of antimonial ores occur in Nevada, Idaho, Oregon, Montana, Alaska, British Columbia, and California. No systematic evaluation of their commercial potentialities has ever been made. The smelting of the ores is a simple process, but no extensive western reduction plant is in permanent production. Most of the United States consumption is imported from South China. The metal is used to harden lead for ammunition and type foundry purposes and for special bearing alloys used in machinery. The possibilities of western antimonial production should be investigated. It is high time we freed ourselves from foreign monopolies that control this mineral.

Quicksilver.

This element is used extensively in explosives manufacture, hence it is essentially a war mineral. It has many other industrial uses. Occurrences are known in many places in Alaska and the various Western States. A systematic survey of all available reserves is desirable. Spain is the largest foreign

producer and the metal has been under close European control.

Silica.

There are many deposits of silica known in the Northwest, of which only a few have been investigated. Much further work is needed in examination of silica deposits to determine those of exceptional purity which may be used for glass and other industrial purposes. No systematic attempt has ever been made to ascertain the best silica supplies available throughout the Northwest.

Copper.

Two of the largest developing copper mines in the State of Washington have been known to miners for thirty years, but only recently have they been prepared for production. There are large copper potentialities in western Idaho, northwestern Washington, southern Oregon, and northern California, Alaska and British Columbia. No systematic study of the west coast copper prospects has ever been made. Some private work has been done, but the information is not publicly available. The large southwestern copper porphyry bodies will be greatly depleted in twenty years and the advisability of advance studies of known copper-bearing territory to determine the best and most economic future supplies is apparent. The heavy sulphide ores found in the Northwest also will afford sulphur for sulphuric acid manufacture, sulphate fertilizers, and many other heavy chemical compounds. Electrolytic refining will use much electric power and electric smelting is a possibility if rates can be obtained as low as $10 to $15 per horsepower year.

Zinc and Lead.

Zinc and lead resources of the Alaskan and West Coast areas are little known, the principal western production now coming from the intermountain belt. A thorough study of all occurrences in western Oregon, Washington, British Columbia, and Alaska, and of some intermountain districts near the headwaters of the Columbia River gateway is much to be desired. Both metals can be produced electrolytically and utilize much electric power. Both are war minerals used in ammunition and mechanical manufactures.

Rate of Crystallization of Calcium Fluoride

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Jensen[1] has presented very complete data on the rate of crystallization of calcium fluoride, but unfortunately has not analysed his data from the point of view of reaction kinetics. Though it is apparent that Jensen's primary concern was not the determination of the order of this reaction, it was thought desirable to analyse his data kinetically, in keeping with Mellor's plea[2] that chemists be not deterred from considering the simplifying kinetics of reaction because of casual mathematical difficulties.

Upon applying the various tests for order of reaction to Jensen's data, there is no question that the crystallization of CaF_2 is bimolecular, in terms of the supersaturation, in the later stages. This region corresponds to the period of growth of the crystal nuclei. The formation of these nuclei in unseeded solutions is reflected as an induction period in the rate curves, and it has been found that a first order equation accounts best for this portion of the curve.

On this basis the rate of desupersaturation due to seed formation will be

$$\frac{-ds_1}{dt} = k_1 s$$

and concurrently these seeds grow to further deplete the concentration according to

$$\frac{-ds_2}{dt} = k_2 n S^2.$$

The total rate of adjustment is:

$$\frac{dS}{dt} = \frac{ds_1}{dt} + \frac{ds_2}{dt} = k_1 S + k_2 n S^2.$$

The number of seeds formed (n) is larger, the greater the degree of supersaturation above a certain concentration, corresponding to Ostwald's supersolubility; and we can set (n) approximately proportional to S; whence:

$$\frac{ds}{dt} = k_1 S + k_2 (k_3 + k_4 S) S^2 = (a + bS + cS^2) S$$

The solution of this differential equation has the form:

$$A \ln \frac{S^2}{a + bS + cS^2} - B \ln \frac{d + eS}{f + eS} = t + \text{const.};$$

which cumbersome form robs it of further utility in the analysis. It does not exhibit directly any convenient inflection point and therefore is not useful in calculating the induction period. This can be approximated by solving the first and second order equations simultaneously for their point of intersection. The result is:

$$\ln(Si + \text{const.}) = -bt_i + \text{const.}^1$$

This expression is as good as Jensen's empirical equation to describe the induction period in terms of the pK of the solution. Better agreement is obtained by throwing the original solution into polar form and rotating to display a maximum corresponding to the terminus of the induction period.

This complexity and cumbersome manipulation will not be given in detail in this place. The conclusion confirmed is, that the precipitation of CaF_2 from supersaturated solutions is a simple combination of unimolecular and bimolecular reactions; corresponding to nuclei generation and growth respectively.

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Interpretation of Effect of Faults on Veins

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There are two kinds of faults, pre-mineral and post-mineral, in their relation to veins. The pre-mineral fault has a bearing on the genesis of the mineral in the vein and may be mineralized itself. It then takes on the nature of a vein itself and may be affected by a post-mineral fault cutting it. A pre-mineral fault becomes a post-mineral fault when it cuts a pre-mineralized vein. This is not a very common occurrence, and this paper on the effects of the faults on the veins has to do only with post-mineral faults.

The large pre-mineral faults of the Belt series area of the Northwest are the evidence of the major earth movement followed by the secondary faulting and fracturing which produced the structures for the ore deposits and also the channels up which ascended the mineral-bearing solutions for mineralization.

The Leonia, Snowshoe, Hope and Osburn Faults are major faults and pre-mineral. Of these only the Snowshoe Fault has been mineralized. In this case the source of mineralization was in a channel along a post-fault dyke and found its way along secondary faults and fissures to the Snowshoe Fault. Where there were none the fault was not mineralized. Even where the mineralizing solutions followed sills and bedding planes the fault was barren. It had no effect upon the veins except acting as the terminus of them. The plan of the fault herewith shows the condition.

It is the post-mineral faults which are of interest to the miner because of their effects on veins and the problem of finding the extensions of the veins beyond the faults and many thousands of dollars and years of effort have been spent in doing it in the hope of finding the same rich mineralization in the faulted sectors. Practically in all cases they have been a disappointment and it is for this reason the interpretation of the effects is important. Each of the cases shown in this paper are actual and can be named if need be.

There have been rules laid down for finding the extension of veins beyond post-mineral faults which are all very good as long as the conditions for which they have been worked out exist. That is not always the case. The simpler way is the study of the contact of the fault and vein. Here the direction of the throw can be determined by the effect upon the vein and the country rock on both sides of the fault. There is a dragging effect in the vein and the country rock as well and frequently minor step faults in the vein just before it reaches the fault. The matter of secondary enrichment on one side of the fault and conditions which prevent it on the other is an important effect upon the vein.

In a Coeur d'Alene mine a vertical displacement for a normal fault acted as a barrier to the downward movement of the meteoric water causing an enrichment of the vein above the fault. The faulted sector was a partly leached primary vein, the values in which were too low to be of commercial value. No improvement in depth can be expected until the water level of the country is reached, at which point there will be a zone of secondary enrichment succeeded by the primary ore below it. As the vein above the enrichment is comparatively short, no such large tonnages of very high grade ore can be expected as that which was the result of leaching the thousands of feet of vein before it was eroded off.

In the case of the reverse fault the

same condition exists. A primary vein of a low grade had been subject to secondary enrichment resulting in a very high grade ore above the fault while below it was in its original condition except a slight loss from leaching, but it was not worth development.

The effect of horizontal displacement by a vertical fault of a dipping vein was to produce two step faults in the same direction as the movement on the other side of the fault. Drag ore was formed leading to the faulted sector. Naturally with the dipping of the vein there would be an enrichment near and along its intersection with the fault on the right side, and none on the displaced sector. This is shown on the vertical projections of the planes of the fault and the vein.

When the ore occurs in shoots there would only be drag ore where the shoot was cut by the fault and there would be enrichment along the fault with depth and of the drag ore the same. The faulted sector would be primary ore without any enrichment. In the particular occurrence I have shown the results were very disappointing but no more than could be expected.

The effect of flat faults on veins is anything but beneficial for the faulted sector. In the case of the steep vein when it reached the fault, it was cut off abruptly and broomed out. The upper part of the vein had good walls and the gangue mineral could be easily separated in milling. Below the fault it was a frozen vein without walls that could be broken to and while it has values high enough to be a milling grade of ore it is expensive to mine, requires fine grinding and is so hard that grinding and milling costs are high.

In the case of the flat vein cut by a flat fault: This is a bedded vein in slates. The vein, while narrow, was pure galena and easily mined in spite of being only 12 inches wide until it was cut off by a fault. Beyond the fault that 12 inches of galena had been broken and numerous small beddings and seams through a width of five feet. It could not be worked at a profit.

In all of these cases cited mining was started on the good side of the fault. If it would be started on the other poorer side it would be enrichment in the faulted sector. But whichever way the fault is approached the same rules apply. Each fault must be studied by itself and much useless work can be avoided if this is done. Having determined the conditions of the vein and the direction of the throw, the effect of the fault upon the vein should be determined with a large degree of certainty.

Soil Erosion in Relation to Overgrazing in Idaho

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Through the mismanagement and excessive overstocking of our western grazing lands, 589 million of the 728 million acres are eroding more or less seriously due to overgrazing. Not only are our ranges threatened with destruction but our forests and watersheds as well. With even the partial destruction of these natural resources the industries correlated with the human welfare of the regions involved become seriously affected. Today Idaho is bearing more than her share (especially in the southern part) of this destructive burden.

Where overgrazing has been practiced in mountainous regions such desirable and once abundant forage species as needle, brome, wheat and fescue grasses are now sparsely distributed. These grasses with rather large fibrous root systems which helped to bind the soil have, in most areas, been replaced by annual grasses and weeds not suited for either soil binding or livestock forage. Forest and brouse lands which have suffered from fire and later by overgrazing have also been seriously eroded. Overgrazing by abundant wildlife on certain winter ranges has more recently introduced a new problem in erosion control.

Sheet and shoestring erosion which follows overgrazing removes the organic portion of the substratum. Shoestring erosion gives birth to gullies that may deepen and widen to such proportions that even the courses of mountain streams may be altered. The water table may also be lowered in certain areas by deep gullies and the desirable deep rooted range species may die of drought and be replaced by the more undesirable superficial species.

In general, Idaho's mountain ranges are highly conducive to rapid runoff after storms because of steep topography.

To correct such a state of affairs as indicated above, the following conservation practices are suggested.

1. Deferred and rotation methods of grazing whereby portions of the range will be used during seasons for which they are best adapted.
2. The grazing of a range with classes of livestock that will utilize only the key species to such a degree that a sustained yield carrying capacity may be maintained.
3. Artificial reseeding of desirable range species on certain badly overgrazed and eroded areas where natural seeding cannot be accomplished. The use of contour-terraces and check dams may also be desirable on such areas. Livestock on such areas should be prohibited.
4. The education of the public as to the value of range conservation.

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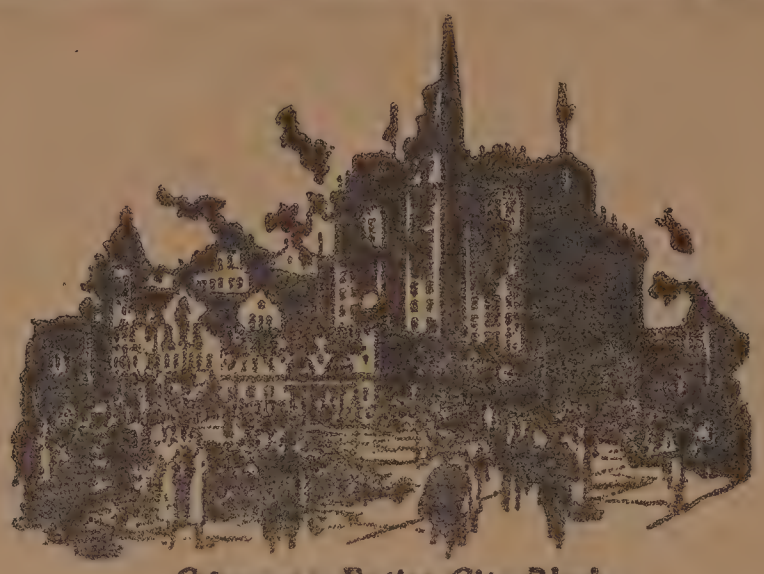

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August, 1939

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∴ *News Notes* ∴

By vote of the Councilors of the Northwest Scientific Association, the name "Lake Columbia" is favored for the slack water that will develop by the construction of the Grand Coulee Dam. In arriving at their decision the first choice of name was given the weight of three points, second choice two points, and third choice one point. On this basis "Lake Columbia" received thirteen points, Thompson Lake eight points, and Lake Garry, Columbia River Lake, Columbia River (as at present), and Sakajawea each three points, and Great Columbia Lake two points.

* * *

The Board of Trustees of the Northwest Scientific Association commissioned Thomas Large to form an advisory committee to guide studies of an ecological nature in this region, with particular attention to the Columbia River Valley. The present composition of the committee selected by Mr. Large is: Dr. Lawrence Griffin, Reed College; Dr. Philip H. Pope, Whitman College; Dr. Willis H. Rich, of Stanford University and Oregon Fish and Game Commission, Portland, Oregon; Dr. Leslie Hedrick, Whitworth College; Mr. Chas. Campbell, of Pullman, but more recently of the U. S. Biol. Survey; Mr. George F. Beck, College of Education, Ellensburg, and Dean A. H. Hutchinson, University of British Columbia, Vancouver, B. C. Others may possibly be included. Dr. Hedrick and Mr. Large plan a reconnaissance early in August in the area to be irrigated, the Grand Coulee and the area to be submerged, with the expectation of determining some of the problems involved.

* * *

Mr. W. A. Rockie, a former president of the Association, will be in charge of a party engaged in soil survey work in the Matanuska Valley of Alaska this summer.

* * *

The National Dairy Association met at the University of Idaho and the State College of Washington June 27-30. Several hundred men from all parts of the country were in attendance.

AUG 17 1939

Old Faithful, An Example of Geyser Development in Yellowstone Park*

By CLYDE MAX BAUER** and GEORGE MARLER***

Undoubtedly the best known geyser in the world is Old Faithful in the Upper Geyser Basin of Yellowstone National Park. The name itself is appealing and suggests regularity and unchangeableness. Visitors usually ask first, "When does it spout?" second, "How high does it go?" third, "How old is Old Faithful, anyway?" This article is presented in an attempt to answer these questions and others of similar nature on this most famous geyser.

Wherever the subject is introduced the geology and the mechanism of geysers seems to be fairly well understood. The fact that hot springs and geysers deposit white earth and mineral around their openings is also well known. Why these deposits are terraces in some places, mounds other places and in still others are cones of symmetrical or unsymmetrical outline, is not so well known. The writers believe there are essential differences between the formation of a terrace, a mound and a cone. But before discussing the deposits of Old Faithful Geyser in detail we will try to answer the first two questions given above.

With regard to the eruption of Old Faithful Geyser there has been considerable misunderstanding among visitors about its interval, duration and height. Some think it plays every hour and on the hour, but of course this has never been the case. Studies made by the Carnegie Institution[1] have dispelled much of the misinformation on geysers, but an attempt will be made here to give correct data on this famous geyser so far as it is in our possession at this time.

A daylight record made during the summer of 1938, between June 15 and September 1 by Ranger Naturalist H. R. Woodward and associates included the recording by use of an ordinary eight-day clock the time elapsed between the high point of one eruption to the high point of the next for 927 eruptions. This data gives the average interval as 66.54 minutes or 66 min. 32 sec. The variations in length of interval observed have run from 34 minutes to a maximum interval of 115 minutes though by far the larger number of periods are very near the average length of 66½ minutes. The duration of the main eruption will run from 2 to 5 minutes and usually there are several preliminary spurts in which the water column will rise from a few feet to ten or fifteen feet. As many as 19 preliminary spurts have been counted though only two or three are commonly noted.

The height of the water column during the main eruption has been measured with a transit, on a number of occasions, and found to vary considerably. The figures run from 116 feet to 171 feet and the average height is usually given as 150 feet, though an insufficient number of measurements have been made to give any reliable figure on the average height. Measurements made in 1870,[2] '71 and '72[3] indicate a height of from 106 to 130 feet. It appears that the height and activity of Old Faithful are very nearly the same as they were when observed by the discovery party in 1870, or 68 years ago.

The amount of water thrown out at an eruption was estimated in 1930 by Drs. Allen and Day of the Carnegie In-

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** Park Naturalist, Yellowstone National Park.

*** Ranger Naturalist, Yellowstone National Park.

stitution, op. cit., at 10,000 to 12,000 gallons, though this figure is based on run-off and does not take into account the water which goes into the air as vapor.

Two minerals are commonly deposited about hot springs and geysers, travertine and silica. Travertine is soft and not given to forming geyser cones, whereas silica is hard and found practically everywhere geysers are found, although not absolutely essential to them. The hot water issuing from the heat, and gas, because of loss of pressure, and by evaporation the volume of water is reduced so that the mineral in the solution is in part precipitated. The splash from the water or even vapor may be very effective in bringing about deposition. These actions aid evaporation and wherever evaporation is, deposition is likewise rapid. A pebble, a twig, or a leaf will produce a ripple and this will increase precipitation. Wherever the curvature of the water surface is bent sharply upward or outward

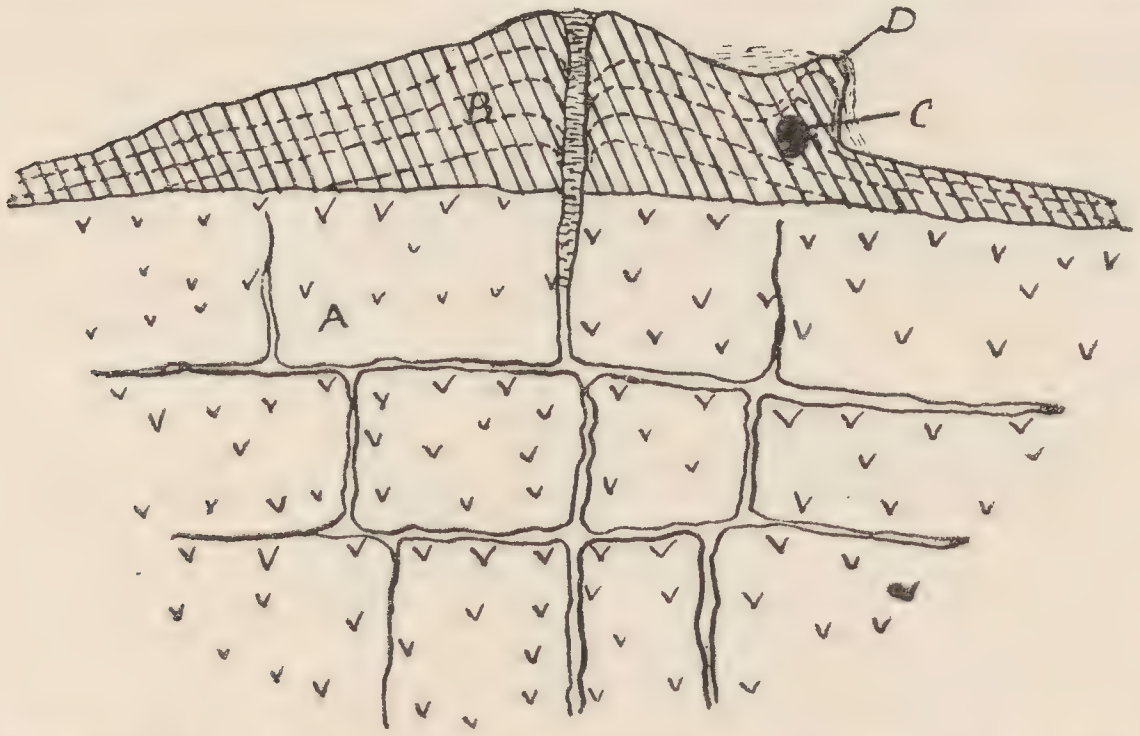

Figure 1. A diagramatic cross section of a hot spring, showing the development of a terrace. (A) Rhyolite. (B) Sinter. (C) Obstruction such as a pebble or a twig. (D) The locus of most rapid deposition coincides with the line of greatest evaporation, where the surface of the water has a decided convex curve. In the case of travertine springs increased loss of gas at this position is an additional cause of deposition.

ground may be saturated with one, or the other, or both. Furthermore, suspended silica is abundant in some of the springs. In general, the movement of hot water from springs and geysers results in the growth of the surface over which it flows causing an elevation known as a mound, group of terraces or a cone. But both erosion and deposition proceed together, with deposition being in the ascendancy only where the water is not too swift. As the water is poured out of the spring it may flow gently or swiftly. In either case it loses evaporation is increased and deposition is accentuated (see Figure 1). Hence, terraces are the natural result of gently flowing water where ripples develop, and small terraces coalesce into larger ones. In reality the small terraces thus formed are most likely to be flat rimmed basins, at least in infancy, and later the "pulpit" terrace develops. After these coalesce the water is spread more widely and thinly than before with the result that a broad terrace is built. The level rim is maintained by the water level. If at any time a part

of the rim becomes too high deposition is slowed up for lack of sufficient water and conversely if the rim is too low additional water, if not too rapid, will increase precipitation and hence a balance is maintained. Recurrent surges from the open pool or fountain type geyser may develop terraces in much the same way.

Mounds result from a somewhat different process, although many mounds have terraces built around them. The most common type of mound is built by a combination of basin, splash, vapor and rivulet deposits. The rivulet erodes on the bottom of the channel and deposits at the edges. After a time the edges extend over the surface of the rivulet and gradually stop the flow which then overflows in a new place starting a new rivulet at a slightly higher point. Many springs thus have two, three or more overflow channels. This spreading of the flow increases evaporation and accordingly deposition. The mound is a result of all the activities of a hot spring or geyser and not of any simple process. The part played by the splash, spray and vapor is extremely important. It is by this means that the saturated water is spread most thinly over solid materials and is therefore evaporated most rapidly. Only the freezing of the water can cause more rapid precipitation than constant splashing.

At this point it may be well to call attention to the character of many of the streams draining geyser basins. They have the character of distributaries found on the flood plains and deltas of large and sluggish rivers, where deposition exceeds erosion. A few examples such as Tantalus, Tangled, White and Rabbit Creeks serve to illustrate the type of braided stream channels where deposition is exceeding erosion. Their drainage basins are gradually being filled with sinter.

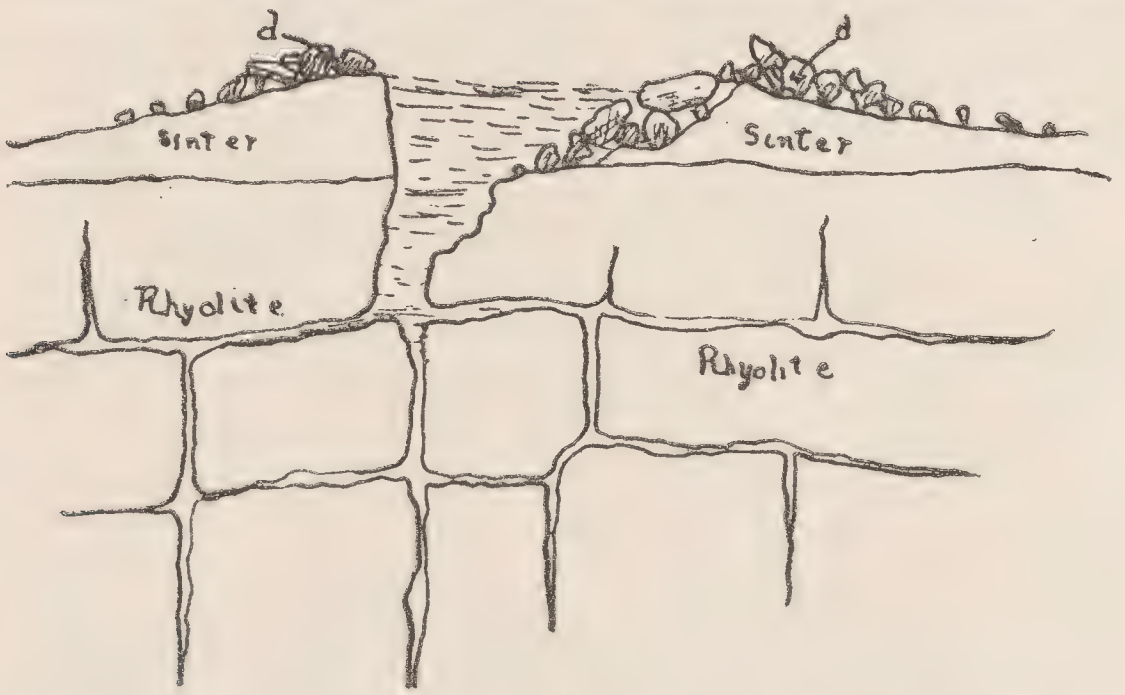

Figure 2. An explosion crater caused by steam. (d) indicates debris thrown out by the explosion. This may happen to a hot spring such as that one shown in Figure 1.

Where geyser action or intermittent spouting is predominate different deposits are the result. Cones, pillars, and various vertical forms are evident. Monument Geyser Basin presents some excellent examples of pillars or chimneys built under the influence of a more or less constant spray.

Thus it becomes evident that the character and structure of a deposit reveals the kind of activity which has produced it.

Where tremendous volumes of water are thrown out with an eruption we can look for erosion instead of deposition.

This is the case around the cone of the Giant Geyser particularly along the south side where a deep gully is now being carved. It is also true on the northeast flank of Old Faithful where the prevailing southwest winds cause a great fall of water. Here erosion has cut a ravine four feet deep into the edge of the mound of a former hot spring. Erosion is also uncovering the stumps, roots and trunks of trees which grew on Old Faithful's own cone not so very long ago. The prevailing direction of the wind being from the southwest causes a great fall of water on the northeast flank, so here erosion is exceeding deposition.

The fact that about one-third of Old Faithful's cone is now being eroded suggested to the writers that a different form of activity has given rise to the main structure than that which is going on today. If we grant that the character of the hot spring or geyser activity determines the form and structure of the deposit which results therefrom, there is a definite suggestion that the water from Old Faithful's orifice has been, up to a few hundred years ago, that of a quietly flowing hot spring or at best of the fountain type geyser such as is displayed at Great Fountain.

Terraces are plainly visible on the sides of Old Faithful's cone up to within two or three feet of its very top. Furthermore, the thickness of sinter such as would result from geyser activity—splashing, spray and vapor—is a mere shell of a few inches to a maximum of ten inches in thickness. As a geyser, then, Old Faithful is only a few hundred years old.

In regard to the presence of partially petrified wood in the form of stumps, roots and trunks of trees on the mound of Old Faithful we find no less than 40 stumps and 60 sections of trees now exposed within 125 feet of the orifice and at least two of these stumps are right at the summit. The protuberances at the northwest of the vent have long been considered as the usual structural prominences built up by geyser activity. Close inspection shows that these lumps are merely tree stumps covered with a layer of geyserite eight to ten inches thick. Therefore, there was a quiescent period prior to the present activity which permitted the growth of

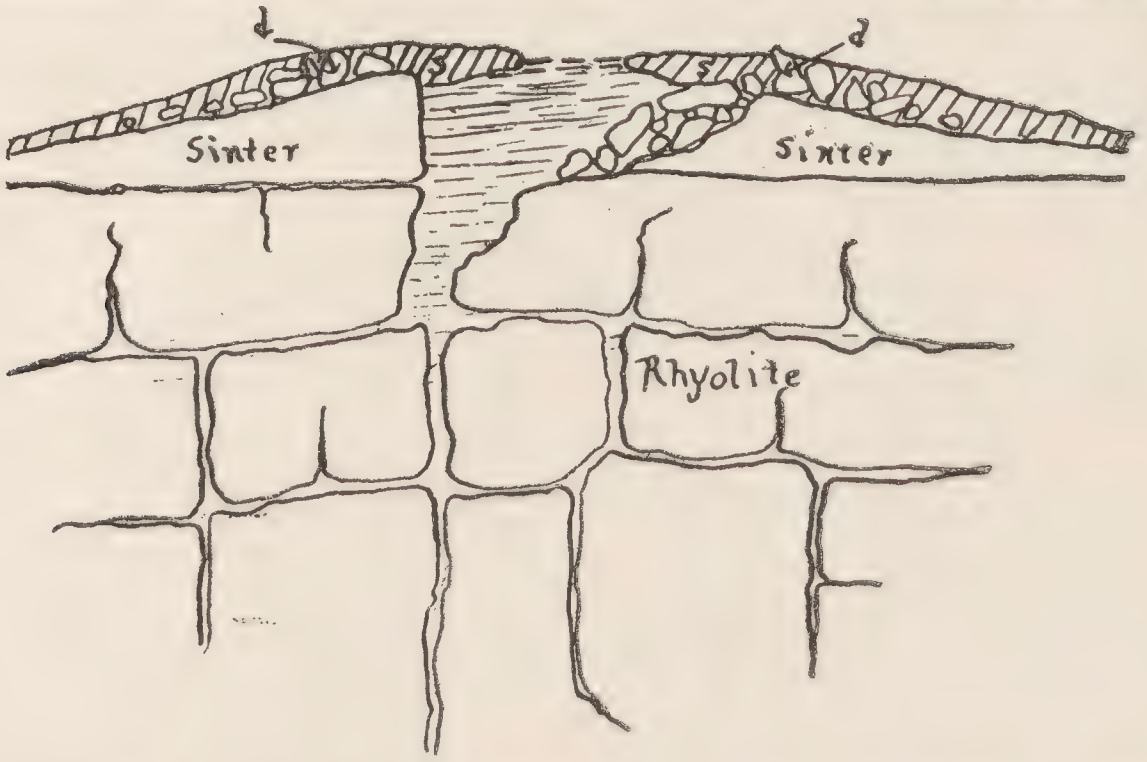

Figure 3. The building of sinter at the water line reduces the water surface and retards the loss of heat. This may cause a surging in the hot spring and later bring about intermittent eruptions. (s) sinter, (d) debris.

trees up to 15 inches in diameter at all points on the mound even up to its apex. From the size and number of the trees present the inactive period must also have been several hundred years in length.

Thin sections of the partially petrified wood were reported by Professor E. A. Longyear of Colorado State College to be of Lodgepole pine (Pinus contorta).

The presence of lodgepole pines on the mound indicates that Old Faithful was a long time as inactive as any of the seven neighboring cones which now lie dormant in the immediate vicinity. The factors that brought about this complete cessation of thermal activity in Old Faithful are rather difficult to ascertain. That the early activity varied between hot springs and fountain type eruption is quite certain from the structure of the mound as now exposed on its partially eroded side.

The usual evolution of a geyser from a hot spring as pointed out by Allen and Day is brought about somewhat as shown in the diagrams, Figures 2, 3 and 4. First, water flows from a simple crack or crevice. As the adjacent rock is disintegrated by the heat and gases, caving takes place. If the current is strong enough some of this is washed away. The residue of the material thus formed may choke or partially obstruct, the circulating water. If sufficient steam is available a preliminary explosion may occur which will produce a crater or open well. Dissolving of silica at some depth will widen the crevices and develop caverns. If the flow of water still remains fairly constant, the crater or well of the spring will gradually close in at the top by deposition of sinter at the water line. After this has gone on for a time the partially covered well retards the loss of heat and again accumulated steam may cause an ex-

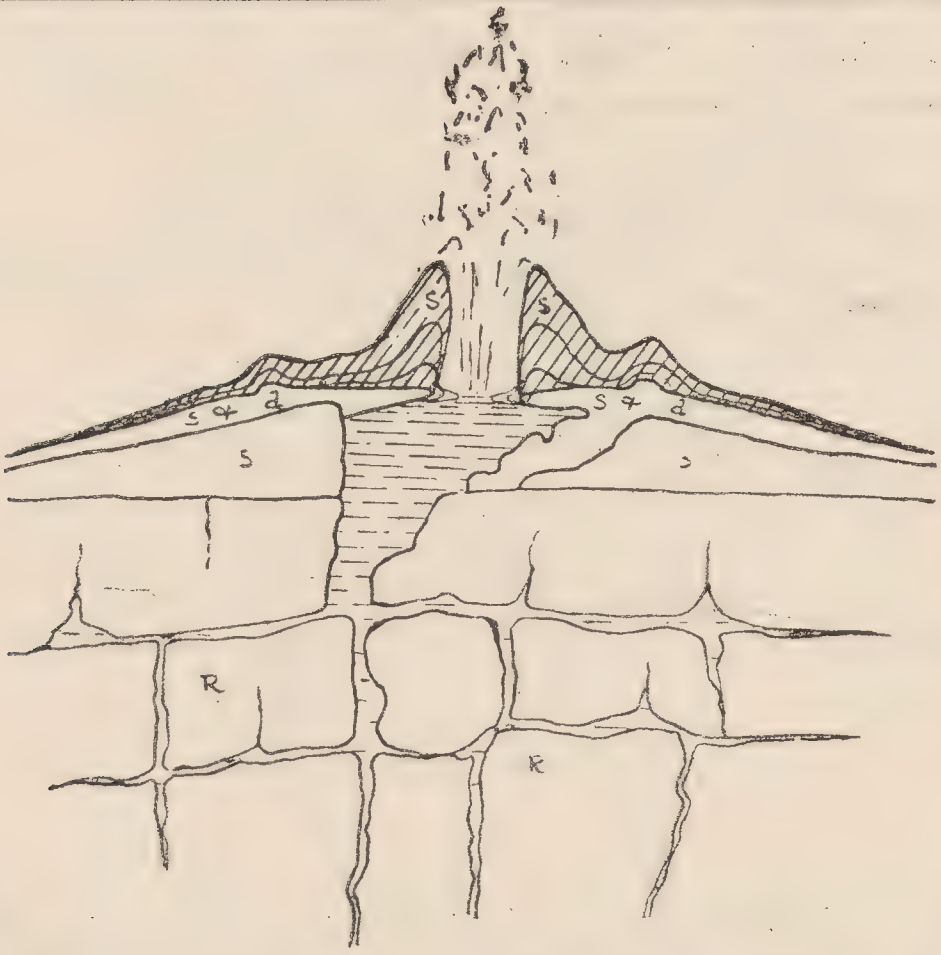

Figure 4. Spray and splash will develop the cone or elevated portion about the orifice. If the eruptions are violent they may cause more erosion than deposition; however, deposits will be formed by the spray and splash during the so-called quiet intervals. (R) Rhyolite, (s) sinter, (s) & (d) sinter and debris.

plosion in which part of the cover is removed, or a surging may set in which will cause a fountain type of geyser to develop as in the Sapphire Pool. As the mound builds higher and the shelf of sinter grows toward the center a sort of nozzle may be developed. Why there should be a total cessation of activity for a time is more obscure. Though it is most likely explained by assuming a diversion of the hot gases supplying the heat or a choking of the channels of water supply, or both. Eventually these factors will cause the extinction of the hot spring or geyser.

The height and size of the mound of sinter on which Old Faithful sets indicates that thermal springs have been active in this place for a very long time. Estimates based on the thickness of silica exposed are not likely to represent the quiescent periods nor take into account the changes in rate of deposition. That thermal activity has been recurrently at work in this locality in excess of 10,000 years seems to be a safe guess. On the other hand Old Faithful as a geyser is a newcomer compared with Giant, Castle and Lion geysers.

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[1] Allen, E. T. and Day, A. L. "Hot Springs of the Yellowstone National Park." Carnegie Institution of Washington, 1935.

[2] Langford, N. P. "The Discovery of Yellowstone National Park." PP. 168-169, 1923.

[3] Peale, A. C. "The Thermal Springs of Yellowstone National Park," U. S. Geol. and Geog. Survey of the Territories, 1878, Part II. PP. 219-220.

The meeting of the Northwest Conservation League was held at the Central Washington College of Education in Ellensburg for three days from July 10th to 12th. In addition to general programs there were section programs on county and local planning, fisheries, wild life, scenic resources, power resources, soil resources, and forest resources. Dr. Paul H. Landis from the State College of Washington spoke on the conservation of human resources. The last general session was devoted to a general discussion of the place of conservation in education in the public school curriculum.

* * *

The article by Rexford F. Daubenmire, of the University of Idaho, in the May issue of "Northwest Science" entitled "Contributions to the Ecology of the Big Bend Area of Washington," was made possible in part by a grant from the research funds of the Northwest Scientific Association.

Some Archaeological Problems of the Montana Plains, With Special Reference to Inscription Cave

By H. MELVILLE SAYRE
Montana School of Mines

For the past five seasons archaeological field work has been carried on by the Montana School of Mines and other agencies, in central and eastern Montana. The very large area to be covered, the difficulty of reaching many sites without long trips afoot or on horseback, together with lack of funds and of workers—all have necessitated making of much of the work a mere reconnaissance.

Only three intensive diggings have been carried on: the first, in the summer of 1936 at Ash Coulee, Prairie County, near Terry, with N. Y. A. help; the second, from June 15, 1937 to the present time at Inscription Cave, Yellowstone County, eight miles south of Billings, with W. P. A. labor and supervision; the third, during 1937, near Red Lodge. I shall consider first the general features as far as we understand them from our preliminary work, and second a brief summary of the work at both Ash Coulee and Inscription Cave.

Even the most cursory examination of both the Yellowstone and Missouri valleys and their tributaries will produce evidence of widespread and intensive prehistoric activity. Camp sites dot the map wherever springs or streams are suitably located on flat ground. Search for stratified open sites such as those at **Stearns Creek** in Nebraska has so far proved unsuccessful, except as will be noted later, at Inscription Cave.

Circles of rocks, the so-called "tepee-rings," mark many of the lowland camps. Typical stone artifacts—knives, scrapers, points, hammerstones, drills, awls, etc.—abound in many of the open camps. Burned and unburned bone, usually deteriorated, and an occasional bone implement or ornament, quantities of chips, and in a few places human burials, mark these open camps. Pottery is found everywhere in southeastern Montana, and as far west as Billings on the Yellowstone, Roundup on the Musselshell, and Great Falls on the Missouri. The greatest concentrations of pottery are at Ash Coulee and at the Hagen campsite on the Yellowstone near Glendive, which has been worked by Oscar T. Lewis, present chief field man at Inscription Cave.

Rock circles and long lines of rock piles are common both on the Plains and in the intermontaine valleys. That some of the "tepee-rings" were actually used instead of stakes to hold down the edges of tepees is an indisputable fact, evidenced by eye-witnesses. Thousands of these circles, however, lie on uplands far from wood or water. In few of these is it possible to find even a flint chip, or the charcoal from a single fire pot. Their usefulness may always remain problematical. Perhaps they served no practical purpose and were merely "spirit tepees." The long lines of rocks, leading as many of them do apparently without pattern, straight over the hills, are also puzzling. Attempts to orient these lines with cardinal directions, with landmarks or burial grounds, or with known sources of water, have all failed. Some of the sets of rock circles and some of the lines of rocks, however, are part of the widespread early habit of buffalo driving or stampeding.

The Buffalo Drive appears to the archaeologist (the man with his eyes on the ground) to have taken three general forms. In the first type, the early Indians made use of a killing fall, a Buffalo Cliff, a sheer drop sufficiently high to kill the animals as they were

driven over. Most prominent of the Buffalo Cliffs in Montana are on the Madison River, six miles south of Logan, on the Yellowstone River south of Livingston at Emigrant, on the Marias River south of Shelby, and on Cut Bank Creek near Browning.

The second type is the Buffalo Trap, into which the animals were driven. Most of these are at the head of narrow coulees back of which are broad, flat uplands. Some still show the holes in which logs were set up and made into a corral. The bison were driven into the log corral and then killed as they crowded along the fence. Some of the traps were probably used in winter, after the snow had filled the heads of the coulees. The bison would bog down and become easy prey for the hunters.

Near these drives, which must have supplied large quantities of meat at one killing, are the old camps and the drying and smoking fires. Some of these camps are marked by ancient rock circles which probably were used practically in the setting up of tepees. Back of the actual spot where the stampede culminated, long lines of rock piles in the shape of a V lead away over the level ground. These may have been markers for those participating in the drive, where they could hide in the tall grass until time to jump up shouting and waving poles, bows, or pieces of leather to frighten the bison into stampeding.

Thousands of arrow-points, most of them quite small, have been dug from the bones at these drives. Careless amateurs have ruined one site after another in their eagerness to collect points, not stopping to think that they might be destroying for all time valuable scientific data. Most of these drives almost certainly were prehistoric. Absence of trade objects and of horse bones in the buried deposits supports this theory. After the Indians got horses, they could ride into the edge of a herd and kill what meat they needed. A few of the drives **were** used with horses and riders to stampede the bison, as late as 1850.

Ash Coulee and Hagen Site.

Both at Ash Coulee, five miles southeast of Terry, and at the Hagen campsite four and one-half miles southwest of Glendive, large quantities of pottery sherds have been recovered—about ten thousand fragments from each site. Along with the pottery are the familiar stone artifacts of the Plains Indians, together with quantities of bone, an occasional bone implement, and parts of human skeletons. Both of these sites, in common with most of those on the Plains, are on open terraces, so that perishable material has been leached away.

At Ash Coulee the old camp has been plowed for forty years until no stratification of the material remains. Mixed through the top soil, twelve to twenty inches thick, is the cultural evidence of extensive occupation over a long period of time. The decorated pottery is all incised in geometric designs. Although the decoration is crude, the ware itself is remarkably resistant to weathering. Ceramic tests seem to show that this pottery was from Fort Union clays which lie under the topsoil and are interbedded in the Fort Union coal seams exposed along Ash Coulee. The tempering is also principally a white sand found along the valley.

At the Hagen site, most of the artifacts have been found in peculiar cone-shaped holes, more than five feet deep, about thirty inches in diameter at the top and sixty inches at the bottom. In these holes are quantities of pottery sherds, most of them cord-marked in patterns entirely different from those at Ash Coulee; hoes made from bison shoulder-blades; fire-burned rocks; and hundreds of broken human bones. Even the jaws are smashed, and some of them burned, indicating possible cannibalism.

Obviously, these semi-agricultural people whose remains are found in south-eastern Montana migrated there from either the East or the South. After many more years of field work, we hope to be able to trace these migration routes, to identify the travellers, and possibly to determine the relative age of the different groups.

Inscription Cave.

The group of rock shelters known as the Indian Caves, eight miles south of Billings, on the old Coburn Hill road, have been known for many years for the red and black pictographs found on the walls of Inscription Cave. The small valley now known as Empty Gulch and the caves themselves have been a favorite picnic ground for Yellowstone County people for many years, but it was not until this spring that the significant discovery was made by H. S. Barringer, of Billings, and Mr. and Mrs. Jim Browne, of Denver, that the floor of the present cave is underlain by a series of remarkable deposits extending to a depth of twenty-five feet or more, and showing human habitation almost throughout.

The caves are really erosional recesses at the foot of the Eagle Sandstone rimrocks. These have resulted from weathering in the soft shaly sandstone below the massive layer which forms the vertical cliffs of the rimrock. This erosion progresses until the shaly layer has entirely disappeared, leaving the roof of massive sandstone. Eventually the caves entirely disappear and a sheer wall of sandstone remains, with huge blocks at its base.

In Inscription Cave the intermittent stream which flowed over the top of the rimrock gradually over a long period of time wore away the sandstone until a large block fell, making a recession of about fifteen feet at the edge of the cliff. This allowed the waterfall, as it struck the large blocks of rock at the foot of the cliff, to turn back into the cave itself, and cut a channel in the lower part of the cave. This channel was cut into the material which had accumulated on the old cave floors, exposing four levels of human habitation extending to a depth of thirteen and one-half feet vertically. Two of the old floors, one at a depth of four and one-half to five feet below the present surface of the lower cave, and the other four to five feet below the first, are continuous and apparently cut straight across the channel of the intermittent stream.

The material exposed was uncovered by the stream pouring over the cliff during heavy rains. As soon as Mr. Barringer and Mr. Browne had satisfied themselves that the old cave floors had been occupied by early Indians, as evidenced by fireplaces, flint and bone implements, and many animal bones, they communicated with me, turned the information over to the Montana Society of Natural History, and urged that excavation be started at once to prevent vandalism by careless amateurs. With the cooperation of the State Highway Commission, which employed Walter T. Vanaman as surveyor, the Montana Society of Natural History, which leased the land for one year, the Montana School of Mines, which sponsored the project, the Billings Commercial Club and other civic organizations which were interested in the value of the work for the tourist trade, the Department of Education and Recreation of the Works Progress Administration, which is furnishing the labor and the supervision, a camp was set up at the caves June 15, with Heilbronner, Phelan, Vanaman, and myself on the ground at all times.

Nationwide newspaper stories were released simultaneously by the Associated Press and the United Press the Sunday after we arrived, and aroused so much interest that more than three

hundred people came out to see what had been discovered. This flow of visitors has continued steadily ever since, until our register now shows that more than six thousand people have visited the caves since June 15. These people have come from all parts of the United States and from several foreign countries. They have been conducted through the caves by one of the men mentioned above, and so far as we know, the visitors have disturbed nothing.

Material as dry as the day is was crushed by rock falling from the roof, fireplaces, beds where Indians had slept, intimate household utensils, and bones of animals burned and still showing human tooth marks, have been found under tons of rock in Inscription Cave. No evidence of contact with white men has been found. Glass beads and metal implements are entirely absent.

Other old camps of the pre-horse Plains Indians have been in the open, exposed to rain and soil alteration. In these the perishable material nas entirely disappeared, leaving only stone, hard bone, and pottery fragments such as those which have been found near Terry and Glendive.

No pottery has been found in the Indian Caves. Apparently the aboriginal occupants were bison hunters with no knowledge of agriculture.

In Inscription Cave have been found buckskin string with braided yucca interspaced with shell from the Pacific coast, amulets made of carved bone incised in a geometrical design on both sides, bone beads of heavy animal bone, incised and drilled, and fragments of hematite showing marks cut with a stone knife.

In the floor beds were fragments of a human skull, human teeth and other human bones. Arrow shafts and waste pieces showing marks of stone knife cutting were found, as were a shaft showing arrow-straightener marks and a broken arrow straightener. There were shavings and chips cut with stone knives and axes, bone dressing tools wrapped with buckskin, pieces of soft buckskin, knives and other implements made of bone, polishing stones, scrapers, knives of various kinds of flint, peelings of Indian turnip and fragments of roasted Indian turnip, bison hoofs, bison horns, and other animal horns. We found bird bones and animal bones of many varieties, from rattlesnake and packrat to bison. Some of the bird bones showed stone saw marks, and there were also bird bone beads. A small stream boulder with pictograph in black was found. We have some very beautiful pictures in red and black on the bottom side of slab rock fallen from the ceiling showing both animal and human figures.

Although more than seven thousand individual specimens have been removed and catalogued, no attempt will be made in this paper to identify tribes on typological evidence. No striking difference can be noted between the stone artifacts from Inscription Cave and those from other prehistoric Plains sites. The cut wood lacks other similar material for comparison. The bone implements also do not differ from those taken from other Plains excavations. A careful correlation with available and properly documented historical and ethnological material may help identify the early occupants of Inscription Cave.

The importance of northwest Plains archaeology lies in possible discovery of early man after his crossing from Asia and his migration up the MacKenzie Valley, as well as in tracing subsequent movements of later peoples. Our preliminary survey shows that only through the intensive field work we hope to carry on in the next few years can these knotty problems begin to be solved.

The Interest of the Federal Land Bank in the Western Range Problem

Paper Presented to the Northwest Scientific Association at Spokane, Washington, December 29, 1938.

By R. B. TOOTELL

Reviewing Appraiser, Federal Land Bank

Our Interest in the Problem.

The Federal Land Bank is interested in the western range problem because it has, for the past twenty-one years, been charged with a semi-public responsibility for making long-term real estate loans on range properties which measure up to satisfactory standards. Since passage of the Farm Loan Act in 1917, the Federal Land Bank of Spokane has made hundreds of mortgage loans on ranch properties in the states of Idaho, Montana, Oregon and Washington. We expect to make many more hundreds of ranch loans in these states in the years to come.

Our interest, at least from the long-run viewpoint, is identical with the interest of the stockman. We are interested in seeing him operate on a stable and profitable basis.

Someone has said that, "in considering the economic and financial problems of stockmen, primary attention should be given the short-run aspects of their problem, since the short-run is the 'last run' for many of them." There is reason to believe that this viewpoint has been too commonly adhered to in past treatment of range problems. The result has not been in the public interest, nor has it been in the ultimate interest of stockmen themselves. As a permanent mortgage lending institution, the Federal Land Bank must place its primary interest and shape its lending policies in keeping with the longer term features of the range problem.

Our Concept of the Problem.

As we view it, the following are some of the outstanding problems of the western range:

1. **Inappropriate land use**—There still is much to be done in differentiating the proper uses of land. Throughout our western range country there are millions of acres which might best be used for grazing but which are being used for other purposes—primarily dry land farming. These low producing cropped lands are intermingled with strictly range land, giving rise to serious problems which, through lack of time, cannot be discussed here.
2. **Confusing pattern of land ownership**—Largely as a result of our Homestead policies, the pattern of land ownership in the range country is undesirable. Too often the land used by one operator is in disconnected and often widely scattered tracts. This greatly increases the cost of fencing and herding, it discourages an intelligent program of rotation grazing, increases stock losses and reduces their weight through long drives. It also encourages competitive bidding for leases, which lessens the stability of the ranch operation.
3. **Uncertain tenure of non-deeded grazing land**—More than half the grazing requirements of the average western ranch come from land not owned by the operator. Forest permits, Taylor Grazing licenses, and public and private land leases supply these requirements. Too often the tenure of these outside grazing supplies is on a short-term basis and for various reasons is not dependable. Grant-

ing that there may be good reasons, in the public interest, why these sources of feed cannot be assured both as to amount and tenure, this nevertheless makes for instability in ranching operations and it constitutes a problem of some magnitude.

4. **High real estate taxes**—Proper land utilization cannot be achieved without corresponding adjustments in real estate taxes. No single factor has more retarded private ownership of range land than that of high real estate taxes. To a considerable extent high taxes on range lands are the result of past attempts to build up substantial farming communities and provide the services of schools and roads in areas which should have been left to grazing use. High taxes not only discourage range land ownership, but they have a depressing effect upon land values.
5. **Fluctuating feed supplies**—Most of the western range, even in normal seasons, receives only the minimum precipitation necessary to produce a modest supply of grass and winter feed. This area is subject to such wide fluctuations in precipitation that years of short feed supplie msust be expected as a certainty. Nothing is likely to be done to increase the rainfall, but the seriousness of the effect of dry years can be substantially reduced by proper ranch organization and management. Reserves of grass and hay are only part of the answer. Ranch organization which incorporates more elements of flexibility is needed. This organization might permit only reasonable expansion of ilvestock numbers during most favorable seasons while still facilitating sharp reduction in livestock numbers without disastrous financial loss and disorganization of the industry during drought periods. At best ranching operations always will be somewhat hazardous.
6. **General overgrazing of the range**—While there may be grounds for debate as to the degree of overstocking on the western ranges in the past twenty-five years, no informed person will deny that in general the range has been sub stantially overgrazed. Excessive erosion is an obvious manifestation of this. Far more subtle, and perhaps even more serious, are the economic effects of this range depletion upon the ranches using the grass.
7. **Use of too much expensive winter feed**—The comparative advantages of the western livestock industry rests on cheap feed—unquestionably upon grass. The long distance from consuming centers places our ranch industry at a disadvantage with the Midwest. Competition in beef and sheep production is being further intensified between the West and the Corn Belt by agricultural conservation programs. This we reasonably may expect in the future.

It costs, according to authoritative statements from research, from five to ten times as much to feed a beef animal on concentrates as it does to feed it on grass. Length of the winter feeding period depends as much on the amount and quality of winter range as it does on the weather. The Norris report on The Western Range states that: "Thirty-five per cent of the feed for western livestock is now supplemental feed raised on crop lands or irrigated pastures—a threefold increase in forty-five years." In many parts of the West the commonly accepted cow unit requirement is a ton of hay. If

adequate range grass were available, the feeding period in many instances could be cut in two and the supplemental feed requirement nearly halved. The economy effected would be substantial—often the difference between profit and loss.

Necessity of circumstances rather than choice is responsible for this increased dependence on hay and concentrates. Competition for land, excessive taxes, and the extension of credit on a per head basis, points discussed in other sections of this paper, have played an important part in forcing the western stockman into this position.

8. **Overcapitalization of ranch properties**—The value of any property is directly related to the amount of net income which it produces over a period of years. Big incomes were made in the western range industry in the days of free range. The amount and frequency of these incomes has been declining for the past forty years as stockmen have come to own more land, pay high taxes, feed more concentrates and pay higher freight rates. If we base our calculations on a price which reasonably may be expected for products of the range, and if we give proper consideration to the high costs of operation, we are forced to the conclusion that the average stock ranch yields a narrow margin of net return.

With the necessity of land ownership to give control of feed, stockmen undertook to block up ranch units. In many instances they were compelled to bid dry farm land prices for purely range land. The World War inflation, with extremely high prices for beef, lamb and wool, also contributed materially to the overcapitalization of ranch properties. Although admitting some outstanding exceptions, I am convinced that the majority of range outfits cost their owners, or are currently valued by their owners, at figures which are out of all proportion to their normal earning power.

9. **Excessive debt**—A natural accompaniment of overcapitalization has been over loaning and excessive debt. Credit extended the range industry in the past has overemphasized mere livestock numbers. Insufficient attention has been given quality of the stock, pounds of beef, lamb or wool produced, the cost of this production and the stability of the ranch operation. Little consideration was given the normal carrying capacity and earning power of the ranch plant. This emphasis on numbers has no doubt encouraged overstocking, range depletion and the increased use of expensive supplemental feeds. Agencies extending credit to the range industry have only recently begun to give proper attention to these more basic factors.

Our Approach to the Appraisal of Range Properties.

The Federal land banks, in conformity with the Farm Loan Act, are permitted to loan up to fifty per cent of the agricultural value of farm land plus twenty per cent of the utility value of the permanent insurable buildings. The Act states that in determining agricultural value, the earning power of the farm shall be a principal factor. Other factors such as location, general desirability, freedom from hazards and many others also are considered. Since 1933 the land banks have been estimating earning power on the basis of "normal prices" for agricultural products. The "normal prices" which we use are in conformity with the 1909-1914 level

of farm commodity prices. Some adjustments for trend are made in the individual commodity prices. These normal prices are, then, our conception of a reasonable long-time expectation for the future.

We define agricultural value as the amount of money a typical operator for the locality and the farm would be justified in paying for it, assuming average crop seasons and normal prices for the products commonly produced from the property.

The first step in appraising a ranch property is to carefully plat the land offered as loan security. On the plat is shown the important physical features, location of buildings, roads, water, etc. Fields of cultivated land, types of range and significant differences in quality of range also are designated on the plat. Tentative values are then assigned each class of land. These are based on the appraiser's experience and judgment gained in appraising similar types of property. Inspection, measurement and valuation of the buildings follows.

In this brief discussion I passed hurriedly over the appraiser's task of estimating range carrying capacity. Actually this is one of the appraiser's most difficult tasks. Few ranchers are able to give definite information on the acreage requirement per animal unit of different types and qualities of range, even on their own property. They do not have occasion to think in terms of unit requirements. The appraiser, on the other hand, must have some common denominator in which to express rate of stocking. Units of measurement such as "forage acres" and "acres per cow month," developed by the Forest Service, are most helpful. The Forest Service has been very cooperative in furnishing information and giving instructions which have helped our ranch appraisers in estimating range carrying capacity and in expressing their estimates in commonly understood terms. Most of our ranch appraisers have been privileged to attend range examiners' short courses lasting from one to six days. The accuracy of the appraiser's carrying capacity estimates has been improved substantially by this instruction.

The next important step is an intensive interview with the applicant. The appraiser obtains a detailed financial statement, listing each asset and liability. He then obtains an inventory of the applicant's livestock by classes and by approximate ages. A listing of the applicant's leases, permits and licenses is made, together with information about their character, quality and season of use. The appraiser then learns from the applicant the details of his plan of operation. These include seasonal use of range, production of hay and winter feeding practices, breeding and marketing practices, death losses, calving or lambing percentages, fleece and lamb weights, etc. He then inquires about the operator's expenses. Some ranchers use the budget method and are able to furnish a very accurate statement of their operating costs.

The appraiser is now ready to estimate the carrying capacity of the plant on a basis which he considers sound for loan purposes. In some instances he learns that the majority of the applicant's grazing is from lands on which he has only short-term leases. In other instances he finds that a substantial part of the outside grazings are represented by privileges or rights which are somewhat permanent and which offer reasonable assurance of availability even though the ownership of the ranch may change.

When the appraiser finishes with his field work he spends many hours, and in fact sometimes several days, analyzing his field data, reaching conclusions and writing his report. He must estimate the number of animal months of

feed which will normally be produced from range and from meadow lands which are offered as loan security. The balance between hay and range and between types of range adapted to different seasons of use must be considered. Finally, he concludes his estimate of the number of head of stock which he feels the plant can be depended upon to support without overstocking the range.

Using information which he obtained from the applicant, combined with his knowledge of ranching practices and standards in the area, he then works out a normal expectancy of income and expenses. Gross income, expense and net income, on a per head basis, he then checks with the same items from comparable ranches with which he is familiar. This check assists him in searching for errors in his computations.

Average net income estimates have two purposes in appraisal work. They first serve as a rough check on value. The preliminary estimate of ranch value which the appraiser made following his field inspection is studied in relation to the net income. This permits a rough estimate of the probable rate of return which average operation of the ranch will pay on the agricultural value. If the rate of return shown is somewhat out of line with returns ordinarily shown on similar ranch properties, the appraiser may revise his first estimates of value in order to bring about a more reasonable relationship. In the end, however, the value which the appraiser decides upon is not the product of an income capitalization process, but is far more the result of his judgment based on experience and many comparisons.

The second use for our average net return estimate is the assistance it gives in reaching a conclusion as to whether a loan should be made, and if so, whether it should be a maximum loan which the value of the ranch will support. Before recommending a loan, the appraiser must be able to answer in the affirmative, this question: "Will this ranch in the hands of a typical operator, receiving normal prices for his products during average crop years, pay all operating expenses including interest on the chattel mortgage, provide a satisfactory living for the operator and his family and meet loan installments?" If it appears that the normal net income will be sufficient and if the applicant measures up to a satisfactory standard as a credit risk, the appraiser may recommend a maximum loan.

I have attempted to do little more than outline what we believe to be the major problems of the western range and to give a brief explanation of our procedure in appraising stock ranches for loan purposes. This procedure, at least in part the product of unfortunate past experience, involves a recognition and a careful consideration of the problems mentioned. The precise manner in which each of the problems is measured and its effect translated into land value is beyond the scope of this paper. It is, however, appropriate to state in conclusion that each and every one of these problems does have a depressing effect on the value of ranch property and hence limits the amount of mortgage credit which safely can be offered.

It is our belief that stabilization of range use, important alike as it is to both operator and creditor, lies in the solution of the more important aspects of these problems. Left to their own devices, distressed ranchers will solve their problems but slowly. Outside influences are helpful in hastening a solution. Land use programs recently undertaken by the Bureau of Agricultural Economics, the Range Conservation program, and state and county land planning programs, combined with the constructive activities of the Forest Service and the comparatively new Taylor Grazing Administration, are fo-

cusing attention on this important prob-ture stabilization of the range industry lem of the West. The outlook for fu-is, therefore. encouraging.

A Prehistoric Hitch-Hiker

By W. A. ROCKIE

Soil Conservation Service, Spokane, Washington

The title of this paper may have caused wonder regarding its character but after repeated study of the set of known facts, and then the evolution of a theory to fit these facts, the entire incident reported here still impresses the writer as a fairy tale.

On February 28, 1938, I, accompanied by four other men, was making a study of the type of material in a road cut 2½ miles north of Touchet, Washington, on the highway toward Eureka. This road cut (25 feet deep) through the Quaternary sediment is characterized by fine-textured sandy and silty deposits, but shows occasional rocks of different sizes, types and materials.

One small rock was dug from the vertical wall about 6½ feet above the base of the cut. It proved to be a dark-colored flat slab of marble about 4 x 5 inches and about 1½ inches thick. Mr. H. M. Wanser, one of the party, began digging at another rock which he saw embedded a few inches from the one found by the writer. The second slab proved to be about 4 x 4 inches and of the same thickness. The two rocks appeared so strikingly similar that the writer, instead of throwing them away after a hasty examination, kept them. Later and closer inspection showed not only that they were of identical material, but that they were two separated portions of what had oncé been a single slab of rock.

These two portions of this rock were found several inches apart, at the same level, with both flat slabs lying in a horizontal position in the Quaternary sediments.

When found, the two rocks did not have the matching faces toward each other, and except for an outcropping corner, they were entirely encased in the massive sandy deposit.

The rock (two pieces) is sufficiently soft that it would quickly show the slightest erosion or weathering, but there is no evidence of protracted wind, water or glacial scouring either on its sides or edges. Its surfaces and edges are so nearly unaltered from their condition when first broken from the parent ledge or cliff, as to indicate that while encased and carried in the ice, it was not rubbed or ground against any rock.

Since the two faces which exactly match are absolutely unworn, while the other faces appear slightly less raw (weathered but positively not rounded) it appears that this one rock became two after it was solidly encased in the ice. Had the break occurred before, all of the faces would show similar age of weathering. It further appears that the two pieces remained contiguous until a few seconds before they dropped to the point where found.

The rock (two pieces) appears as though it must have broken from some cliff in northern Washington, or northern Idaho, in British Columbia or elsewhere to the glacierward, fallen onto the snow, been buried in that snow until it was compressed into ice, then transported southward in the Continental Ice-Sheet. the particular ice that con'ained this rock sooner or later breaking off from the parent body, floating either in lake or stream or in combination of both lake and stream, far beyond the front line of glaciation,

to that portion of the prehistoric lake site at which the two pieces were recently found.

The Quaternary sediments at this point are of lacustrine origin, and the lake in which these two rocks were deposited as judged by the usually fine-textured nature of the deposit, must have been rather large and the deposit at this point certainly occurred in quiet waters. In order for these two parts of one slab of rock to arrive (considering their condition when found in this still-water deposit), they must have been held in the grip of a floating berg from the glaciers to the northward, must have been released (vertically above their location when found) by the melting of that ice and then they must have dropped from the ice raft which had served as their vehicle of transportation.

In an attempt to fit the evidence found into a logical series of happenings, the following outlined sequence of events has been imagined:

1. A slab broke from its parent cliff somewhere in the glaciated country northerly from Spokane.
2. This slab appears to have fallen into a snow bank at the foot of that cliff.
3. The snow bank was gradually compressed into ice.
4. This ice was a part of the Continental Ice-Sheet that covered much of the United States and Canada, or it was one of the out-flowing ice spigots of that ice-sheet which may have appeared as a typical valley glacier.
5. The ice moved forward over a period of thousands of years until that portion of the ice-mass that contained this rock was part of the floating front of a glacier emptying into a lake or stream.
6. Probably during the period when this ice raft was an embedded part of a moving glacier, some strain or stress cracked the rock into two pieces, but both pieces still remained imprisoned in one cell.
7. The surrounding cracked ice refroze into a solid brick.
8. An iceberg or ice raft (probably rather large because it traveled at least several hundred miles) containing this rock broke from the parent mass and floated away.
9. Traveling either by lake or possibly also partly by stream, the berg or raft drifted southward.
10. It was constantly decreasing in size due to melting.
11. At a point directly above that where the rock was found, the raft was floating on the quiet deep water of a lake when the particular ice which held the rock in captivity melted, releasing the rock.
12. The two pieces of the rock settled to the bottom of the lake, fluttering downward and coming to rest a few inches apart on the lake floor where the glacial flour (which the waters of this lake undoubtedly carried) soon encased and buried the two pieces until the highway was cut through this deposit in recent years.

THE FAIRY TALE IS ENDED.

Adjustments from a Farmer's Standpoint

By CARL KING
Agricultural Adjustment Administration

Changes are the order of the day. We are going through a period of readjustment or change which amounts to almost a revolution in many ways.

In our physical set-up, relating particularly to farmers, perhaps the greatest change we must recognize is the changing picture in Europe. From all indications, the picture does not favor large exportations of our surpluses, especially with the United States changed from a debtor to a creditor nation. Farmers, generally, have not recognized this shift.

As a further consideration, power farming is here to stay, but we have not yet learned to live with it. I have sometimes wondered which was the master, the man or the machine. Up to the present, it is debatable. The machine has brought its problems along with its benefits. It has brought to a head our surplus problems as well as our Soil Conservation problems, much quicker than would otherwise have occurred. We can deplete our soils far faster than formerly and also to a further degree, at an apparent profit. By being able to create optimum conditions for the liberation of the last ounce of plant food, we can more effectively decrease the organic matter content of our soils, thereby making them more susceptible to erosion.

All this is cumulative, and with each passing year action is speeded up from an erosion standpoint. Too, the surplus problem is very much in the fore right now, so much in fact, that it is causing meetings of farmers and headaches for the Agricultural Adjustment Administration and other agencies.

Another change on the physical side of the picture is that of science. We are told about using up surpluses to manufacture goods, but so far it seems to have worked the other way. Science has created substitutes for agricultural products which are competitive, rather than using up surplus agricultural products. Examples are rayon, and in Germany, making wool out of dried skimmed milk, and the Duponts threaten to revolutionize the sheep industry of this country with a synthetic wool.

Another change is the change in diet of the people. They no longer eat the energy-giving foods that were so essential under the more rugged existence of using man power; nor do they now need, with closed cars and comfortable heating systems, the heavy garments of wool and cotton.

Another change to be reckoned with is specialization of farming. Our farms are turning into factories of one or two essential products rather than remaining on a self-sufficiency basis as formerly. A wheat farmer, for instance, is becoming less interested in a garden or in curing his own pork, and in many other things that can be done more efficiently through specialization.

A farmer may be able to do these things cheaper (by working for nothing), but the demand is keener for a fair price for the thing he has to sell. A poor price of any one major product disrupts our economic rhythm far more today than formerly. As specialization increases, to the same degree does our independence decrease. We are becoming more and more interdependent and the disruption of any service is thereby becoming more keenly felt.

But, perhaps most important is our whole idea about land policy. The nation has had a policy founded upon exploitation. Farmers, generally, are still thinking in terms of exploitation, even though much progress has been made. The consensus of opinion among farm-

ers seems to be that of a Shylock in regard to the land—to exact all at whatever cost to the future, to be content only when every bushel of soil-depleting crops has been taken from the land. But, by economic pressure, it has had to be so, the argument runs. Granted that this is a very vital factor, it still has not proved out even when the economic pressure lifted.

The point in question—that of conservation—was not considered during good times. During the war, a period of high prices, or in any other period of good prices, we have not seen any evidence of adjustments for the good of the land. A farmer having a little extra money over and above expenses has used it as a small down payment on some more land. This has been the rule rather than the exception even when the original holding has a substantial mortgage on it and needed improvements. Farm mortgages are created to a large degree in good times and paid off during hard times.

The question arises, how far can we go with a fellow whose wants for land are never satisfied, who keeps the land mortgaged to the hilt and then must in turn exact the last ounce of organic matter from it?

About all any farmer wants that I've run across so far is all the land that joins him. This has gone on at the expense of the soil. The speculator has also added to the problem.

But even this is changing. High and low prices have been the farmer's and the soil's greatest curses. The high prices of the war left the farmers and their soil much the poorer. We will never know the amount of this bill, but farmers and their soils will be paying for it for years to come.

The Agricultural Adjustment Act passed by the last Congress recognized all this and more and is a great step forward toward stabilizing commodity prices and land values, reducing speculation and encouraging conservation. It is new and a radical change, but this effort of Congress merits our earnest consideration and support. The developments in land policy, new to the United States, are old business in foreign countries where more limited land resources and denser populations long ago forced the recognition of the importance of land planning.

We are only in the formative stages as to a national land policy, but we are attacking it from many points. From the great droughts of 1934 and 1936 and recent floods, we have become land conscious in these United States.

An American who went to Europe to study conditions in rural communities was deeply impressed. He observed that many of the farms visited had been in the same family for several hundred years. The improvements generally were of brick and tile, with considerable steel framework construction. The production of similar land was about double that which is obtained in America. One particular farm had been handed down from father to son since the eleventh century.

It seems to me that we in this country have lost a part of our love for the land because the supply of land has been considered to be inexhaustible. Now we realize our mistake and we must begin to conserve our ownership, as well as the land itself.

Our traditional attitudes toward land ownership and land use must change before a real soil conservation program will work. We cannot change ownership every seven years as we have in the past. We must learn to love the land before we can best use and conserve it.

We must become soil-conscious to the extent that we are holding the land in trust for a short span of life. Our old ideas of holding land ownership in fee simple must change, denying the right of a person to do as he pleases with

land regardless of the nation or society. This is a slow process which borders on what we call our freedom or liberty, but if we as farmers insist on soil destruction and waste and final abandonment, what is the price of that liberty or freedom? I fear that the cost is much too great for this or any other nation to bear.

If there is one lesson in history that is unmistakable, it is that national strength lies very near the soil. All wise plans must be based on the hypothesis of continued national existence, yet we know that even in our own country the way we have cropped our soils has been anything but toward permanency.

We farmers are but the custodians of our soil, and the farmers of the nation, under our system of ownership, hold the balance of the power, not in numbers or in voting power, or from an economic standpoint, but from the control of the nation's greatest asset—the soil.

Extension of the Known Range of Ribes Coloradense Colville

By EDWARD L. JOY[1]
Bureau of Entomology and Plant Quarantine

On July 8, 1927, during the course of scouting for white pine blister rust in northern Idaho, specimens of a species of **Ribes** uncommon to this region were collected by H. N. Putnam[2] and M. C. Riley[3] along Rattle Creek, a tributary of Lightning Creek, about 15 miles north of Clarks Fork, Idaho. This location is within 2 miles of the Idaho-Montana line at an elevation of 4,200 feet. A week later, on July 15, Putnam collected the same species from near Revett Lake, which is within one-half mile of the State line 12 miles east of Murray, Idaho. These two locations are about 55 miles apart by air line. A thorough scouting of the Lightning Creek area by the writer and others in 1928 disclosed the fact that this **Ribes** grows in the upper reaches of most of the tributary streams throughout about 12 miles of this drainage.

In February 1929 a specimen of the material collected near Revett Lake in

Ribes coloradense Colville Growing in Western Montana.

1927 was referred to the Bureau of Plant Industry for identification. In turn it was submitted to the late Frederick V. Coville, the outstanding authority on this genus of plants. His determination was that the species is **Ribes coloradense,** a plant he had collected and first described as a species in 1901.[4]

In 1935, with the extension of blister rust control work in western Montana, the finding near Spar Lake, about 16 miles south of Troy, of a species of **Ribes** not generally prevalent in that part of the region was reported. This location is just across the State line only a few miles east of the Lightning Creek drainage in Idaho. With the collection of complete specimens of this species, the material was submitted for identification in 1933. This also proved to be **R. coloradense.**

A review of literature in which the range of **Ribes coloradense** is recorded indicates that this species has previously been reported from only Colorado, New Mexico, and Utah, where it grows in the mountainous areas at elevations ranging from 9,000 to 11,000 feet. To this is now added northeastern Idaho and northwestern Montana in mountainous areas at elevations of from 3,500 to 5,500 feet. Further work in this added territory will shed light on the full extent of the species distribution there. There still remains a stretch of 700 miles or more between the two regions of its occurrence from which there is no reported collection of **R. coloradense.**

In the Idaho-Montana range of this species it has been found at the following specific locations:

[1] Forester, Northwestern Region; [2] Senior Pathologist, Central States Region, and Associate Forester, Northwestern Region, White Pine Blister Rust Control, Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

[4] Proceedings of the Biological Society of Washington, 14: 3. 1901.

Idaho	Bonner	Rattle Creek	T. 57 N., R. 3 E.	4,200	July 8, 1927
Idaho	Shoshone	Revett Lake	T. 49 N., R. 6 E.	4,000	July 15, 1927
Idaho	Bonner	Wellington Creek	T. 57 N., R. 2 E.	3,600	Aug. 21, 1928
Idaho	Bonner	Gordon Creek	T. 58 N., R. 2 E.	5,000	Aug. 23, 1928
Idaho	Bonner	Lunch Creek	T. 58 N., R. 2 E.	5,200	Aug. 23, 1928
Idaho	Bonner	Moose Creek	T. 58 N., R. 2-3 E.	5,400	Aug. 18, 1928
Idaho	Bonner	Deer Creek	T. 58 N., R. 2 E.	4,800	Aug. 20, 1928
Idaho	Bonner	Quartz Creek	T. 58 N., R. 2 E.	4,500	Aug. 20, 1928
Montana	Lincoln	Spar Creek	T. 29 N., R. 34 W.	3,500	1935-1938
Montana	Lincoln	Cub Creek	T. 29 N., R. 34 W.	4,500	1935-1938
Montana	Lincoln	Whoopie Creek	T. 29 N., R. 34 W.	5,000	1935-1938
Montana	Lincoln	Hiatt Creek	T. 29 N., R. 34 W.	4,500	1935-1938
Montana	Lincoln	Spruce Creek	T. 29 N., R. 34 W.	4,500	1935-1938
Montana	Lincoln	Keeler Creek	T. 30 N., R. 34 W.	4,000	1935-1938
Montana	Lincoln	Cheer Creek	T. 30 N., R. 34 W.	5,000	1935-1938
Montana	Lincoln	Cliff Creek	T. 30 N., R. 35 W.	5,000	1935-1938
Montana	Lincoln	Halverson Creek	T. 30 N., R. 35 W.	5,000	1935-1938
Montana	Lincoln	Benning Creek	T. 30 N., R. 35 W.	5,000	1935-1938

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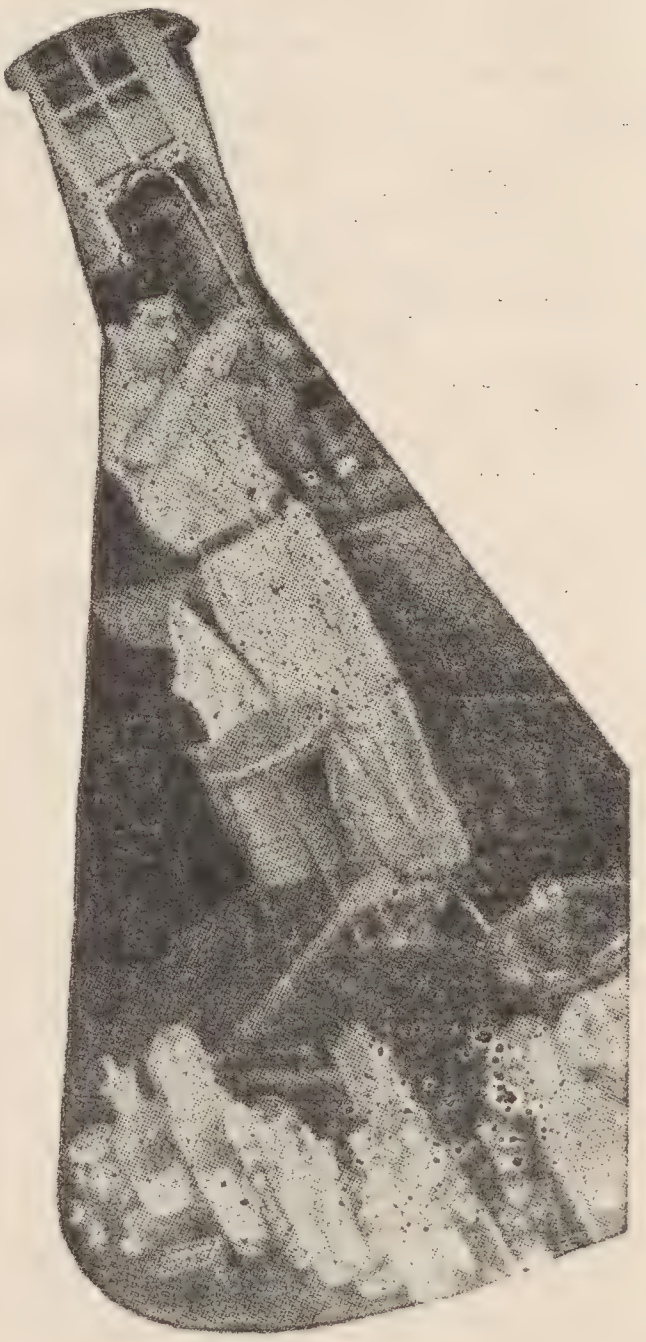

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*Simpson, C. T. and Chandlee, G. C., *Ind. and Eng. Chem., Anal. Ed.*, 10:642, Nov. 15, 1938.

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Additions to the Annotated Catalogue of the Vascular Plants of Benton County, Washington

By GARLAND M. POWELL
Oregon State College

The following additions to the list prepared by St. John and Jones[1] on the vascular plants of Benton County, Washington were determined from collections made by R. Sprague near White Bluffs on August 14-20, 1938. Specimens are filed in the Herbarium, Oregon State College, Corvallis, Oregon.

GRAMINEAE

Agropyron Elmeri Scribn. Scattered, in dry soil, Hoffreider island, Aug. 16.

Agropyron inerme Scribn. and Smith. 2½ miles SE of White Bluffs at Gable ranch, Aug. 16.

Agropyron Smithii Rydb. Hoffreider Is. Aug. 16, 2½ miles NW of White Bluffs, Aug. 18.

Eragrostis cilianensis (All.) Link. Richland.

Setaria verticillata (L.) Beauv. Along irrigation ditch 2½ miles NW of White Bluffs, not common.

CYPERACEAE

Eleocharis acicularis (L.) Roem and Schult. Common along slough at Hoffreider Is., Aug. 16.

Scirpus occidentalis (S. Wats.) Chase. In pond at McGraw place near White Bluffs, Aug. 14.

JUNCACEAE

Juncus effusus L. Hoffreider Is. Aug. 16.

RANUNCULACEAE

Ranunculus flammula var. **intermedia** Hk. Along slough 2½ miles SE of White Bluffs, Aug. 16.

CRUCIFERAE

Rorippa pacifica Howell. Along slough 2¾ miles SE of White Bluffs, Aug. 16.

LEGUMINOSAE

Astragalus sp. A showy tall species growing in colonies at the edge of drying ponds ⅓ mile SW of White Bluffs. Flowers cardinal when fresh. Aug. 14.

Vicia villosa Roth. A common escape in meadows where there are irrigation projects. Aug. 14.

CONVOLVULCEAE

Cuscuta pentagona Engelm. var. **calycina** Engelm. was found on the following unreported hosts in this county: **Franseria acanthicarpa** (Hook.) Cov., **Agropyron Smithi** Bybd., **Xanthium italicum** Mor., **Salsola kali** L. var. **tenuifolia** G. W. F. Mey. These were found on Hoffreider Island. In 1913 a dodder was very common on **Lupinus ornatus** on Chamber's Bar. In 1911 dodder was seen on red clover **(Trifolium pratense)** and on mammoth clover (**T. pratense** var.) at White Bluffs in sufficient quantities to necessitate plowing under the fields.

COMPOSITAE

Ambrosia artemisiaefolia L. forma **villosa** Fern. and Griscomb. Near White Bluffs, Aug. 14.

Aster chilensis Nees. Common along sloughs east of White Bluffs, Aug. 16.

Sonchus arvensis L. White Bluffs, Aug. 14.

[1] St. John, Harold and Jones, George Neville. An annotated catalogue of the vascular plants of Benton County, Washington. Northwest Science 2: 73-93. 1928.

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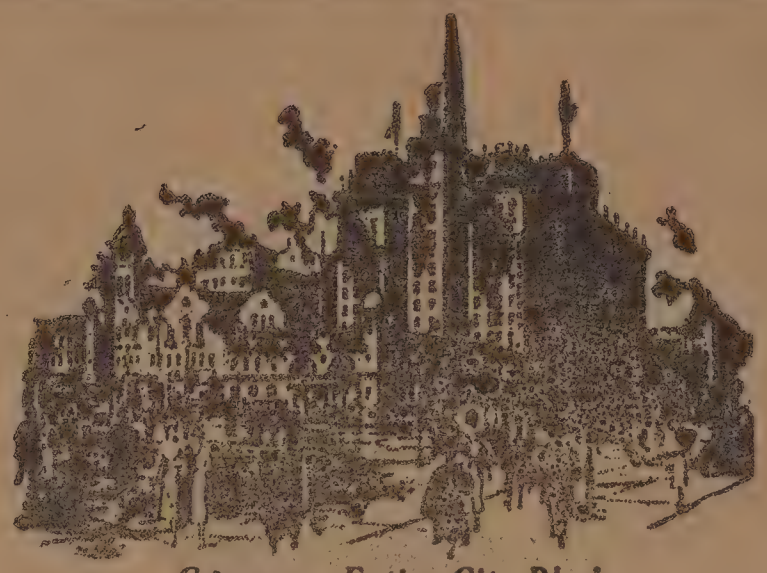

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Association Meeting, December 27 and 28

The Sixteenth Annual meeting of the Northwest Scientific Association will be held Wednesday and Thursday, December 27 and 28, 1939 in the Davenport Hotel, Spokane, Washington. It is hoped that a large number of members and their friends will be present for the meetings. The Association grows mainly by personal contact of member scientists with others in the various fields of scientific work in the Pacific Northwest.

The program of general session speakers as arranged at the time this number of Northwest Science goes to press, includes Dr. A. G. Coons, Professor of Economics at Claremont College, who will give the main address at the first general session. J. H. Ramskill of Montana State University, will give the retiring president's address on the subject "Recollections of Burma". Harold E. Abbott of the Spokane City Planning Commission will also speak at one of the general meetings on "Conservation and the Landscape Architect". Mr. Abbott is a graduate of America's foremost college of landscape architecture, Harvard.

The Associated Engineers-Northwest Scientific Association joint luncheon will be held Wednesday noon, December 27, but the program feature has not yet been announced.

Seven regular section meetings will be held, and a program from the Northwest Conservation League will be a guest feature. Owing to the annual conference of the Pacific Coast Economic Association meeting in Pullman and Moscow, December 27, 28 and 29, the Social Science section will hold one meeting in Spokane for a short program and then officially adjourn so that a joint meeting with the P. C. E. A. can be held at the University of Idaho on December 28.

W. B. MERRIAM,
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SUMMARY AND BIBLIOGRAPHY OF OREGON LAKES

SUMMARY

The largest natural lake is Klamath Lake.

The deepest is Crater Lake, 1996′+.

The shallowest is probably Alvord Lake (dry most of the time).

Lake County has the greatest number of large lakes.

The highest above sea level is in the crater of the South Sister, 10300′+.

The coldest lake is the one in the crater of the South Sister—ice all year.

The hottest lake is probably Hot Lake, near La Grande.

The saltiest is Alkali Lake in Central Oregon.

The two most beautiful large lakes are Crater Lake and Wallowa Lake.

Perhaps the most irregular in shape is Lake Tahkenitch.

Wallowa County has perhaps the greatest number of small lakes (over 100 mapped by Forest Service), though Lane County might even surpass it if we had an accurate count of them all.

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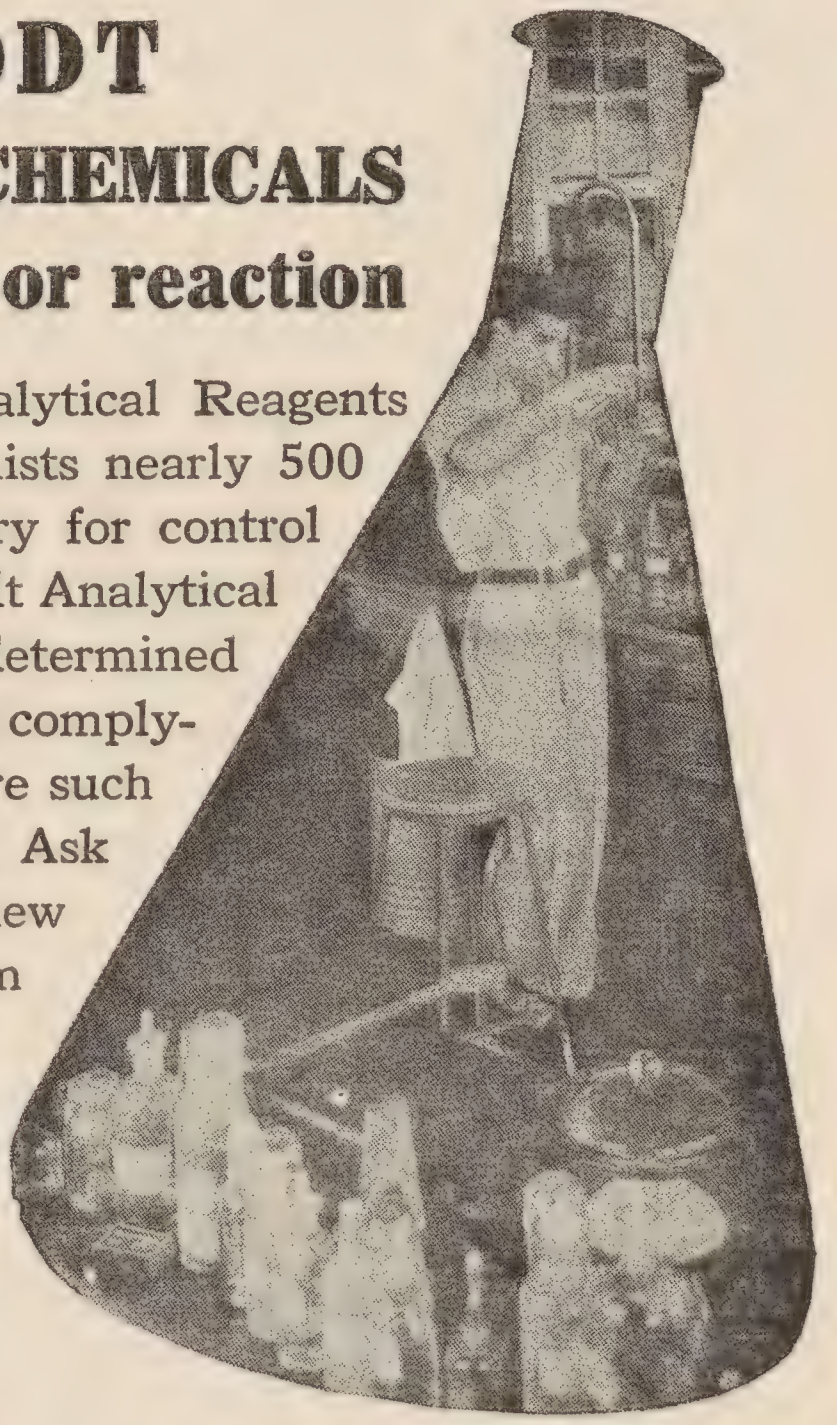

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Report of Board of Trustees to the Membership of the Northwest Scientific Association

By ROBERT F. E. STIER

The membership of the Northwest Scientific Association should be vitally interested in the disposition of their yearly contributions. It is the aim of the Board of Trustees to allocate these funds as judiciously as possible. This year your funds have been allocated to a diversified group of projects that we feel will give not only our Association valuable information but should be of value to the entire community and district in which the data was gathered.

There were four projects for which a total of $210.00 was granted. Dr. R. F. Daubenmire is continuing his Ecological Survey of the Columbia Basin District. The work done last year was reported to us at our last meeting. It showed that our small sum of money was well placed. At our annual meeting this year we are anticipating not only a very valuable scientific contribution but an exhibit of his surveys of the past summer.

The Association has given Dr. J. H. Ramskill several grants toward his study to determine what correlation exists between climate and the development of hypoderm structure in the needles of the Western Yellow Pine. Some previous reports have been made and we anticipate his valuable contributions which are of common interest. These results should be of unusual importance to the question of the kind of tree that is necessary in the extensive reforestation projects.

To the geologist and those interested in palentology should be the investigations of Dr. N. J. Gillette of the University of Idaho who will report his findings of the study of the Fossil Flora of the Latah Formation. We hope to have him exhibit some of his findings.

Some very important surveys pertaining to the Columbia Gorge have been considered and this year we contributed a sum of $100.00 to members of the Department of Botany of Washington State College to make a much needed botanical survey of the lands that will become history by the inundation of the waters of the lake above Coulee Dam. We anticipate a fine report and exhibit. It is our hope that more than just local interest will be created in this project that we have sponsored.

The resources for research in this section of the country are unlimited. Much fundamental investigation such as Dr. Daubenmire's and that of the Botany Department at Washington State College is still necessary before we can know the enormous possibilities of the Coulee Dam and its effect upon the fish, water fowl and even the types of crops it will grow most profitably.

We have in our organization a nucleus of scientists, the equal of any in the world, if we could but put them to work on just a few of the essential problems, resulting from the Coulee Dam Project. The possibilities of applying the limitless amount of electric energy to industry, farming, mining, etc., could be anticipated. More important perhaps is the prevention of the pitfalls of other irrigation and dam projects. Sportsmen should concern themselves regarding the results of the inundation of the land by these waters. What will become of the fish life in these deep lakes? How can our game fishing be improved? Are the types of game fish now available suited for the future of these waters? How about our migratory fowl? Should there be protection on the new pot holes that will be formed? All these questions and many more should be answered before the dam is completed.

We should be able to interest some of our governmental agencies, private and community welfare organizations and certainly the Chambers of Commerce of the towns that will be affected, to contribute something financially toward these problems. Certainly their money would be well spent in scientific endeavor.

Any active organization be it religious, service or scientific, can only exist because it has something active to accomplish. Ours is the advancement of scientific research. We will be known only by the things we accomplish or be held in esteem by the service we have rendered to a community and mankind.

May we as your Board of Trustees urge your earnest support in not only encouraging scientific research in our active projects but help us in our endeavor to find more active donors for future research projects?

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VOL. XIII NO. 4 DECEMBER, 1939

MEETING OF NORTHWEST SCIENTIFIC ASSOCIATION
Davenport Hotel, Spokane, December 27 and 28

Lakes of Oregon

By WARREN D. SMITH and WILBUR GREENUP
University of Oregon

INTRODUCTION

In many publications on the geology and geography of Oregon references have been made to various lakes. Some of these have been rather extended notes, and others have been mere allusions consisting of only a line or two of text, while many of our lakes have been reproduced in photographs. Up to the present time there has been no attempt to present systematically the data concerning the general subject of lakes in Oregon. It is proposed in this paper to give a preliminary presentation of the data we now have, and some interpretations, with the purpose that persons interested, or who may be working in the field, can secure additional information concerning the lakes referred to in this paper, and others which may not be mentioned here. Only recently has such an attempt been made in California, when the late Professor W. M. Davis published a very illuminating treatise on this subject. While the authors do not presume to be able to duplicate the contribution of Professor Davis, we feel that it is time that some attempt be made to present in a connected and concise way the geological story of the many interesting lakes that we have in this state.

We have drawn upon various sources —the reports of the U. S. Geological Survey, the former Bureau of Mines and Geology of Oregon, the present State Department of Geology and Mineral Industries, the News Letter of the Geological Society of the Oregon Country, and our own personal observations in every county in the state.

Many people look upon lakes simply as very interesting natural features, perhaps also valuable for fishing, without realizing the very great economic importance of these bodies of water, and so we have added a chapter on this subject. A fairly complete list of the more important references to Oregon lakes in the geological literature will be found at the end of the paper.

The authors will greatly appreciate any constructive criticisms or new data pertinent to this field.

LIFE HISTORY OF LAKES

Every lake, regardless of its origin, is in the course of time doomed to inevitable extinction. No matter how broad or how deep the original depression, it will in time be reduced to topographic maturity, old age, and eventual extinction. In general, land forms can be traced through a definite cycle of successive stages, but interruptions usually

occur before complete erosional modification has taken place. However, in the case of lakes the process is carried on with greater relative speed; many lakes reach extinction even before surrounding topographic features have lost their youthful characteristics. (Pl. II-a.)

In general, two factors are chiefly responsible for the ephemeral existence of lakes: the filling in of the lake basin and the lowering of the outlet. On the one hand tributaries of a lake are nearly constantly filling its basin with mechanical sediment in the form of deltas, and finer suspension material which tends to settle in the quiet waters of the lake* and at the same time the lake's outlet is lowered by the action of the water leaving it, though the erosive action of clear water is not nearly as great as it later becomes when material is picked up by the stream. Other conditions affecting the rate of down-cutting of a lake's outlet are the gradient of the stream and the type of material through which it must cut. A rapid stream tends to lower the outlet with more vigor than a slow stream, and soft material will be removed more readily than hard, resistant structures.

Under the humid conditions of western Oregon both of the above factors operate toward reducing the capacity of lake basins. Deposition is the more important factor, however, because of the fairly large amount of rainfall and the fact that the waters leaving the basins are clear and have relatively little power to erode.

The formation of peat bogs is another factor which is operative in filling lake basins, particularly in western Oregon. Lakes too small for active waves and currents, where conditions favor the profuse growth of vegetation, fall in this group. In particular, some of the small lakes of the Oregon coast are being filled by the accumulation of peat. Here the conditions of temperature and humidity are favorable to an abundant growth of peat-forming plants. The peat consists of partly decayed and disintegrated plant remains which, in the case of lakes, accumulates around the edges and on the bottom until the basin is completely filled with the material. (For those interested in further detail, we suggest the report of Soper and Osbon.)

The trend of glacial cirque basins toward extinction is relatively rapid, due both to the lowering of their outlets and sedimentation. Their outlets descend steep slopes, often by a series of cascades, to the main valleys below, while at the same time the upper portions of the basin are being filled with alluvial material which varies greatly in size. The filled-in upper portion of a cirque basin or rock basin is usually surfaced with a rich green meadow, usually crossed by one or more small streams which exhibit in miniature the characteristic features of a stream in a stage of late maturity or old age.

LIFE HISTORY IN ARID REGIONS

In arid regions the life of lake basins is usually considerably longer than in humid areas where greater amounts of rainfall result in a more speedy modification of topography. Another factor, interior drainage, is characteristic of much of the arid region in southeastern Oregon and, consequently, the basins are not decreased in area by the lowering of outlets. This distinctive feature extends the life of lakes of the area, leaving the rate of deposition as an important factor. As a basin is filled the surface area of the lake is expanded and the resulting increased evaporation often reduces the lake to a playa. These nearly flat areas are often dry the greater portion of the year, and sometimes are covered with a shallow

*This silting up of lakes becomes, of course, a serious problem in the case of reservoirs. All lakes are settling basins.

sheet of water only after thunderstorms, thus leading a distinctly ephemeral existence.

In some of the dry regions of the world, wind action is strong enough to remove more material from the basins than is being added by deposition, hence extending the existence of the basins indefinitely. Among the arid basins of our own state, however, there is no evidence of appreciable removal of material by the wind, though rather vigorous whirlwinds and duststorms have been observed by the senior author in the Abert basin and others of the area. (Plate II-b.)

Shorelines (Plate II-a), much higher than the present valley floor and lake levels indicate the presence of extensive lakes over much of the area of the Great Basin within rather recent geologic time. Of these former lakes the best known are Lake Bonneville of Utah and Lake Lahontan, the scattered fingers of which formerly covered most of Utah and Nevada, and even a short distance into Oregon. In Oregon, Catlow Valley and its former lake receive our greatest attention at present because of recent archaeological discoveries directly bearing on the antiquity of man in this part of the world. The question arises whether the former Catlow lake and its contemporaries occupying adjoining basins in southeastern Oregon represent the Pluvial period following maximum glaciation during the Pleistocene period, as do Lake Bonneville and Lake Lahontan, or whether they were due to still later climatic changes.

CLASSIFICATION OF LAKES

The classification followed here is a modification of one proposed by the late William Morris Davis:

(1) Lakes due to original irregularities on new land surfaces.

Irregular depressions in lava surface.

(2) Lakes formed in the course of erosional development and deposition.

Lakes due to stream action:
- oxbow lakes.
- flood plain lakes.
- lakes due to damming by alluvial fan.
- plunge pool lakes.
- delta lakes.

Coast dune lakes.
- (a) damming of stream mouths.
- (b) advance of sand barriers on a sloping surface.

Glacial lakes.
- (a) erosional basins.
- (b) deposition of glacial debris.

(3) Lakes due to interruptions of normal erosional development.

Fault block lakes—
- those impounded by a minor fault.

Lava dammed lakes.

Crater lakes.

Hot spring lakes.

Landslide lakes.

Beaver dam lakes.

Man-made reservoirs.

This classification is based upon genetic considerations and does not depend upon considerations of size, depth, beauty or utility with which the layman is mainly concerned. The **origin** of the lake is the prime consideration with the physiographer. Its beauty and utility, although important, are of secondary significance to him.

DESCRIPTION OF LAKES IN OREGON

Lakes Due to Irregular Depressions in the Surface.

Some of the lakes of the High Cascades are due in part, to irregular depressions in the surface, but in most cases they have been caused by lava damming or by moraines. Lakes like Waldo and Odell are good examples of irregular lava surfaces.

A number of small lakes which occur about the base of Ollalie Butte on the crest of the Cascade divide appear to be of very recent origin and seem to be in depressions of irregular lava surfaces rather than due to glacial erosion. Williams[22] describes them as being scattered about at various elevations, many of them without outlets. Besides pointing out their recency of appearance, Williams also recognized that they may have been greatly modified by glacial action. It is difficult sometimes to establish either of the factors as the predominating one. Several other lakes along the crest of the Cascades may be similarly classified, though in some cases lakes which exist quite near them may be typically glacia lin character or in other instances clearly caused by lava flows.

Lakes Formed by Erosion and Deposition.

The next group is that of those found in the course of erosional (and depositional) development. Here we have three subdivisions to consider: (1) those due to stream action (2) coast lakes and (3) those of glacial origin.

In the first sub-group we may consider several examples. Ox-bow lakes abound and shallow flood-plain lakes and marshes are common near the banks of base-leveled streams, such as the Willamette River between Eugene and Oregon City. As the Willamette flows through the relatively soft alluvial material of its valley floor its meanders migrate laterally and downstream, rather rapidly in comparison with the rate of change in most land forms. The migration of meanders is greatest during the high water stages of the rainy spring and winter months. It is also during these stages that the river cuts new channels through the narrow necks of meander spurs, barricading the openings to the abandoned portions of the channel and leaving them as "oxbow" lakes when the flood subsides. The name is an accurate description of their typical shape. Oxbow lakes along the course of the Willamette River are shown in Plate I.

Horseshoe Lake. Further changes in the course of the river and accompanying shifts of the water table, in addition to the filling in of plant remains, are continually changing the status of numerous oxbows from lakes to meander scars which retain excellent topographic expression of their origin. The life cycle of these lakes is exceedingly short; several generations of the remnants of the cut-off meanders can be seen within a short distance from the present channel in nearly any area. The successive stages can be readily seen in good aerial photographs (Plate I-a). An excellent example of an oxbow lake, partly filled in, is Horseshoe Lake, across the Willamette River from Dayton.

Also typical of old age streams are the shallow flood plain lakes which are prevented from draining directly to the streams by the natural levees which are built up during flood stages. When the rivers overflow, much of the material making up the excessive stream load

carried during high water is, due to the decrease in velocity, deposited near the stream banks in the form of natural levees. These are slightly higher than the surrounding flood plain and often result in poor drainage of broad areas.

Flood Plain or "Saucer" Lakes along the Columbia River. There are numerous flood plain lakes along the lower portions of the Columbia River. These have also been termed "levee lakes" because of their origin, described above, or "saucer lakes" because of the shape which they often assume. Some areas near Portland which formerly were flood-plain lakes and marshes have been drained for agricultural use.

Alluvial Lakes. Though most of the lakes originating with the development of river valleys are associated with streams which have reached a stage of old age, there are lakes in Oregon caused by the action of youthful streams. Mann Lake and Juniper Lake in the northern part of Alvord Valley have been caused by alluvial fans. The alluvial material has been carried from the mountain blocks facing each other (east and west), to meet in the center of the valley and pond the spring freshets. Further mention of these lakes is included in the treatment of lakes found in the southeastern part of the state.

Plunge Pools. Another type of lake sometimes occurring in the development of a youthful stream is the "plunge pool" lake below a dry falls. Perhaps the best known of this type of lake are the lakes in Washington below the Dry Falls in the course of the Columbia River during the glacial period. An example in Oregon is the fairly large pool beneath the Lower Falls of the McKenzie River a few miles below Clear Lake. The falls are usually dry during the period of drouth in the summer and fall, but the pool and stream below the pool are fed by springs, due to the permeability of the lava over which the stream flows.

Miniature examples of plunge pool lakes may be found in the beds of mountain streams of semi-desert areas such as southeastern Oregon during the dry summers when the streams disappear and the pools below falls remain for a time, perhaps throughout the entire season.

Coastal Lakes. Various forms of sand barriers are responsible for the lakes of our Oregon coast. In general, the lakes of the coastal area have been formed by one of two methods: by the damming of the mouth of a stream emptying into the sea, or by the advance of a sand barrier on a sloping surface to form a basin. The former are the larger and hence more noticeable of the two types; the latter are usually small though widely distributed in the areas of drifting sand.

Drowning of the river valleys in the submerged portions of the Oregon coast has made the river outlets very sluggish and hence unable to keep their mouths free from drifting sand and from their own sediments. It is in the instances where sand barriers have succeeded in completely blocking the former stream mouths that the larger coastal lakes have been formed. In addition to the deposition of material at the river mouths the formation of impounding barriers has been brought about by shore currents, wave action and wind action. Many of these lakes, such as Lake Tahkenitch (Plate I-b), have extremely long shorelines indented by "fingers" of tributary valleys, filled with fresh water, but otherwise resembling in appearance the marine estuaries of a typical submerged coastline. Just north of Cape Blanco, Floras Lake and New Lake show similar characteristics.

Other examples of lakes caused by the damming of stream valleys are Sutton and Mercer Lakes, about three miles north of Florence, and Siltcoos Lake and others a short distance south

of Florence. Lakes of the same type also occur near Lakeside, a short distance north of Coos Bay. A summary of the characteristics of Mercer Lake is generally applicable to the coastal lakes of the type under consideration. It occupies a former stream valley and its tributaries, and is dammed by sand a slight distance above sea level while its bottom is considerably below sea level. In its upper indentations the deposition of erosional material by the lake's tributaries has filled in much of the area of the former water-filled valleys. Callaghan[3] states that "Bailey Creek Valley contains a rich alluvial flat over a mile long. The partial filling in of this and other tributary valleys with depositional material indicates that the lake level has been stable for a considerable length of time and also indicates its extent when first impounded by its present sand barrier.

Perhaps some of the best examples of lakes formed by the advance of sand barriers on a sloping surface are three small lakes just north of Sutton Lake—Buck Lake, Lake Marr, and Lily Lake. In the other areas of advancing dunes along our coast there are lakes of this type, usually quite small but rather numerous in their distribution. Most of these lakes have no outlet other than seepage through the sand to a lower basin or directly to the sea.

Clear Lake in this same general area appears to have had a somewhat different history, in that subsidence has evidently played a part.

Glacial Lakes.

The glacial lakes in Oregon are of two principal kinds: (a) cirque lakes, or those due primarily to erosion by glaciers, and (b) morainal lakes, those formed wholly or in part by the damming of water courses by the deposition of morainal material. We have many of both kinds in this state. Chain or rock basin lakes, due to excessive jointing in places, are also important and numerous, perhaps more so than true cirque lakes.

First we shall consider the cirque lakes. These are practically all high level lakes, being generally above 3000 feet and for the most part between 5000 and the summits of the highest mountains. Sometimes we find these in a staircase arrangement, one above the other, where glaciers have been stationary long enough to have developed an amphitheater at the head of the ice stream. These lakes are generally not very large—at the most only one or two miles in diameter, and many of them only a few hundred yards across. Their shape is quite irregular, but with a tendency to be somewhat rounded and some of them almost circular. Though they may be relatively deep near the center they are for the most part comparatively shallow. Their enclosing basins often have precipitous walls, particularly at the upper end. The lower end generally is low and consists of a hard rock lip or **riegel.** Generally this lip is notched, and an outlet stream flows down through this notch to the next bench below, where the water may go into another similar basin.

Such lakes are particularly well-developed in the high Wallowa Mountains, but are found also at many places in the Cascades. A very few are found in the Siskiyou Mountains and practically none as far as is now known in the Coast Range. A type example is Aneroid Lake at an elevation of 7300 feet above sea level. Aneroid Lake is a particularly fine example, and is easily accessible by horse trail—some two to three hours from Wallowa Lake Lodge. One goes up the east fork and climbs up over several heavy morainal deposits to reach it. The lake now occupies the lower portion of the cirque amphitheater, the upper part being made up of detrital material washed down from the back country and is now a somewhat stony meadow.. This

lake is one of the well-known fishing lakes in Eastern Oregon. It is stocked principally with eastern brook trout. A depth of 60 feet is recorded for the lake and it has an average depth of perhaps 50 feet. Another lake of this type in that region which is of considerable interest is Ice Lake, which has some beautiful falls at its lower end, but the finest examples are in the area called the Basin, just below Eagle Cap, at an elevation of above 8000 feet. For the most part these nine Basin lakes are in the granodiorite area.

For an example of a morainal lake we have one of the finest anywhere in the United States in Lake Wallowa. This lake is approximately four miles in length, and has a maximum width of a little over three-fourths of a mile. It extends almost due north and south, but has a distinct curve to the northwest in its lower portion. In the deepest place it is 283 feet, and this was found after several scores of soundings* had been taken at different points in the lake. One complete series was taken, from one side of the lake to the other. This body of water has been formed as a combined result of the damming of the Wallowa River by two huge lateral moraines, one on each side, and a lower terminal moraine at the north end. These moraines are remarkable features of the local topography, resembling huge railroad embankments or highway fills. At the upper end the east moraine is nearly 900 feet above the surface of the lake. At the north end the moraines are much decreased in height approaching the level of the outwash plain. The moraines were composite, that is made up of the coalescing of morainal material deposited at different times, and probably representing several different advances and retreats of the ice tongue. The deflection of the axis of the lake to the northwest undoubtedly was due to the deposition of morainal material at the mouth of the canyon in greater quantity on the east side, which would tend to deflect the ice stream more and more to the westward**. The general topography of this locality and details of the features of the moraine can best be seen by referring to the block diagram made in 1927 by Mr. James Stovall to accompany his Master's thesis on the physiography of that region. (Fig. 2.)

A fine highway skirts the eastern side of this lake up to the head of the lake where the road ends within a short distance, and people wishing to explore the country must proceed the rest of the way afoot or horseback. This is an excellent fishing lake and vacationists use it also for boating and swimming. The valley towns below the lake have put in a dam, which has raised the level of the lake somewhat higher, and regulates the height and flow of the water. It is thus a fine reservoir for irrigation water. A large irrigation ditch has been built leading away from its north end to carry water out to the fine outwash plain to the north of Joseph.

Other morainal lakes in Oregon are not so regular in shape as this one. In fact most of them are quite irregular, and they differ greatly in size. As far as we know no accurate count has ever been made of the number of these lakes in Oregon, but it would be the writer's guess that all the glacial lakes in the state would total several hundred, and perhaps more than a thousand. In fact they make up the principal type of lake in the state.

Lakes Due to Interruption of Normal Erosion Processes.

Rift Valley and Graben Lakes. In the southeastern portion of the state a

*Taken in 1927 by the senior author and party of students.

**It has been suggested that as the west side of this glacier was partly in the shade, the east side being in the sun and has the heat reflected from the moraine as well, there would be an acceleration of melting and deposition on the east side.

number of lakes are found in depressions due to the northernmost extension of Basin and Range faulting. Though the nature of the Basin and Range faulting is not entirely agreed upon, its effects are clearly apparent. In the Oregon portion of the Great Basin the crustal movement has resulted in seven major depressions which trend in a general north-south direction. Eastward in order from the Cascade Mountains these include the Klamath Graben, the Summer Lake-Chewaucan Marsh-Abert-Goose Lake downdropped area, Warner Valley, Guano Valley, Catlow Valley, Alvord Valley, and McDermitt Valley. Fresh appearing escarpments throughout the area testify to the fact that the faulting has been fairly recent.* A generalization of the structure of the area is shown in Fig. 3.

The depressions have been partly filled with material eroded from their enclosing escarpments of Tertiary lavas and the present lakes rest on these **bolson** deposits.

The amount of aggradation, that is, filling of the basins with erosional material from nearby escarpments, can only be estimated since definite measurements of the filled in material have not been made. However, it can be reasonably assumed that the alluvial material on which most of the lakes rest extends to a depth of at least several hundred feet. In Nevada and Utah in the central portions of the Great Basin the generally greater amount of infilling of the individual basins indicates a longer period of aggradation and, at the same time, possibly earlier faulting. The comparison may also be extended to the fault blocks; in Oregon they are much less dissected by erosion than in some other portions of the Great Basin.

*Faulting in the Great Basin has continued to the present time; the major uplift of portions of the Sierras, and perhaps the Cascades also, have been quite late.

Some of the lakes occupying the "fault basins" ordinarily contain water all the year round, but others disappear during the dry summer months or in an exceptionally dry year. The nearly level floors of these dried up lakes are termed **playas.** There are also numerous playas which contain water only in the spring and early summer or after sudden thundershowers. During the hot, dry summer months characteristic of the region the crusts of the playa mud-flats become baked very hard and crack in a somewhat regular hexagonal pattern. Even when perfectly dry, due to mirage these flats often appear from a distance as extensive bodies of water. Attempts have been made, without success as yet, to find varves in the playa beds which can be used in dating their deposition.

The Abert Lake fault basin was regarded by Russell[10] as being probably the most typical example of the fault basins which are so numerous in the Basin and Range region of the western United States. Figure 3 illustrates the structure of the basin and its infilled bolson deposits on which the present lake rests. Like the other lakes of the region Abert Lake is typically shallow, averaging not over 10 feet deep in its deepest areas. Its length is parallel with its enclosing escarpment of an eastward dipping fault block, which rises several hundred feet above the lake floor. In an average year Abert Lake extends about 15 miles, however, much of the lake evaporates to playa flats during each summer. A salt whirl on these flats may be seen in plate II-b. The lake extends southward nearly to Valley Falls, located at the junction of highways 395 and 31.

Summer Lake, Goose Lake, and the Warner lakes occupy basins which are structural equivalents of that of Abert Lake. The other depressions of the Oregon portion of the Great Basin are similar in being fault block basins, but are

Plate 1A. Oxbows along the Willamette Valley. (Photo by Brubaker Aerial Surveys.)

Plate 2B. Lake Tahkenitch, Oregon Coast Highway. (Photo by Brubaker Aerial Surveys.)

Plate IIa. Shorelines of former Catlow Lake.

Plate IIb. Salt Whirl on Albert Lake.

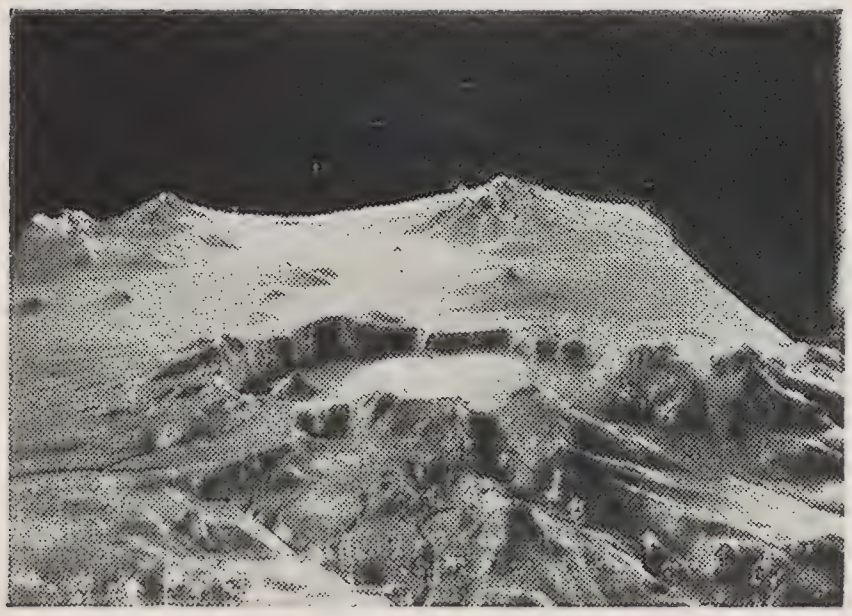

Plate 3A. Photo of Relief Moodel of Crater Lake.

Plate 3B. Part of south wall of Crater Lake showing Phantom Ship and Sun Notch.

Figure 1. Diagram illustrating life history of a lake.

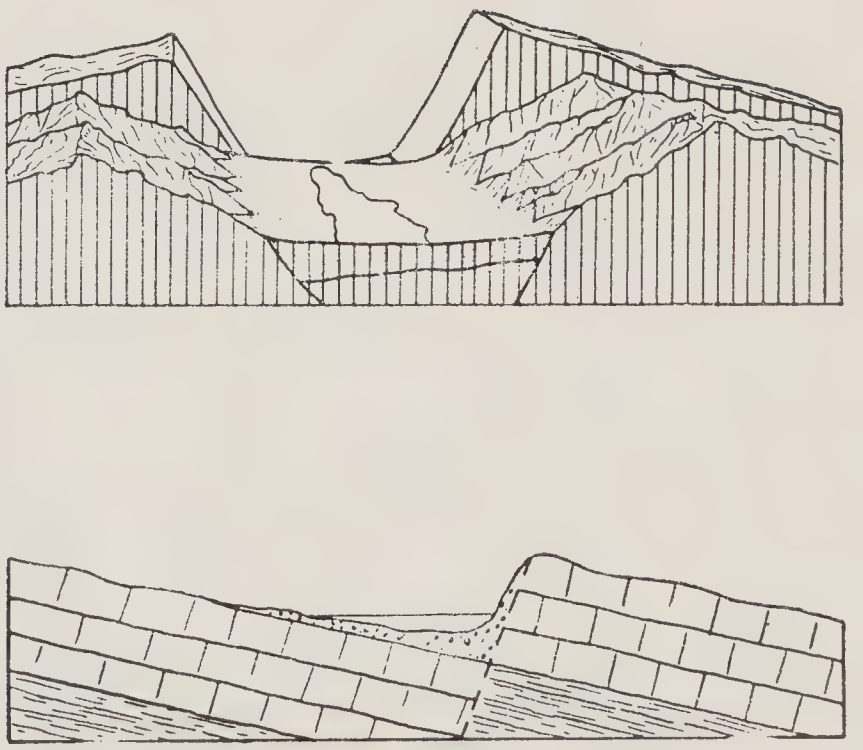

Figure 3. Diagrams showing structural conditions causing some of the lakes of southeastern Oregon.

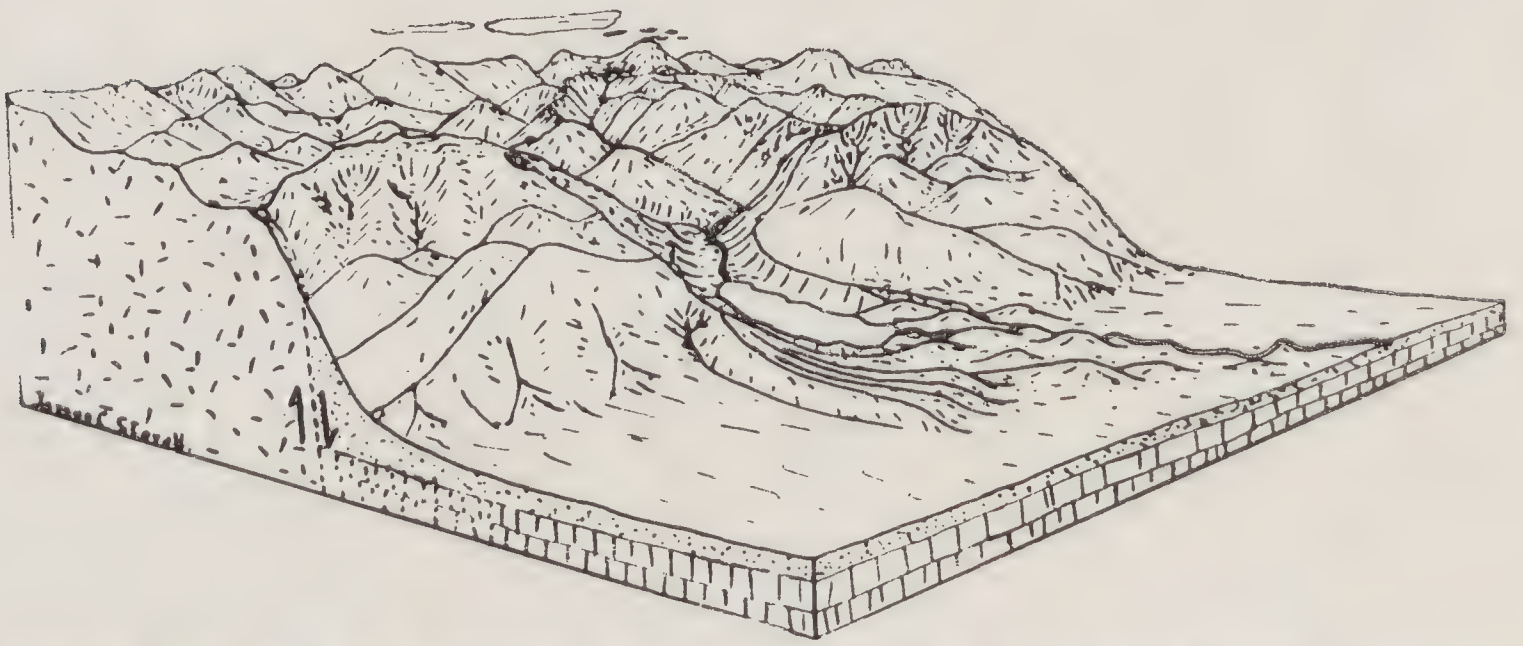

Figure 2A. Block diagram of Wallowa Lake and moraines. (Drawn by James C. Stovall.)

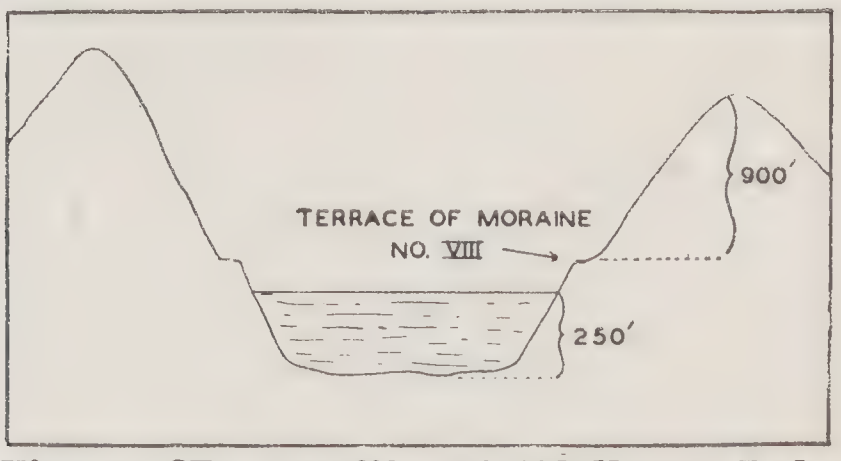

Figure 2B. Profile of Wallowa Lake and moraines.

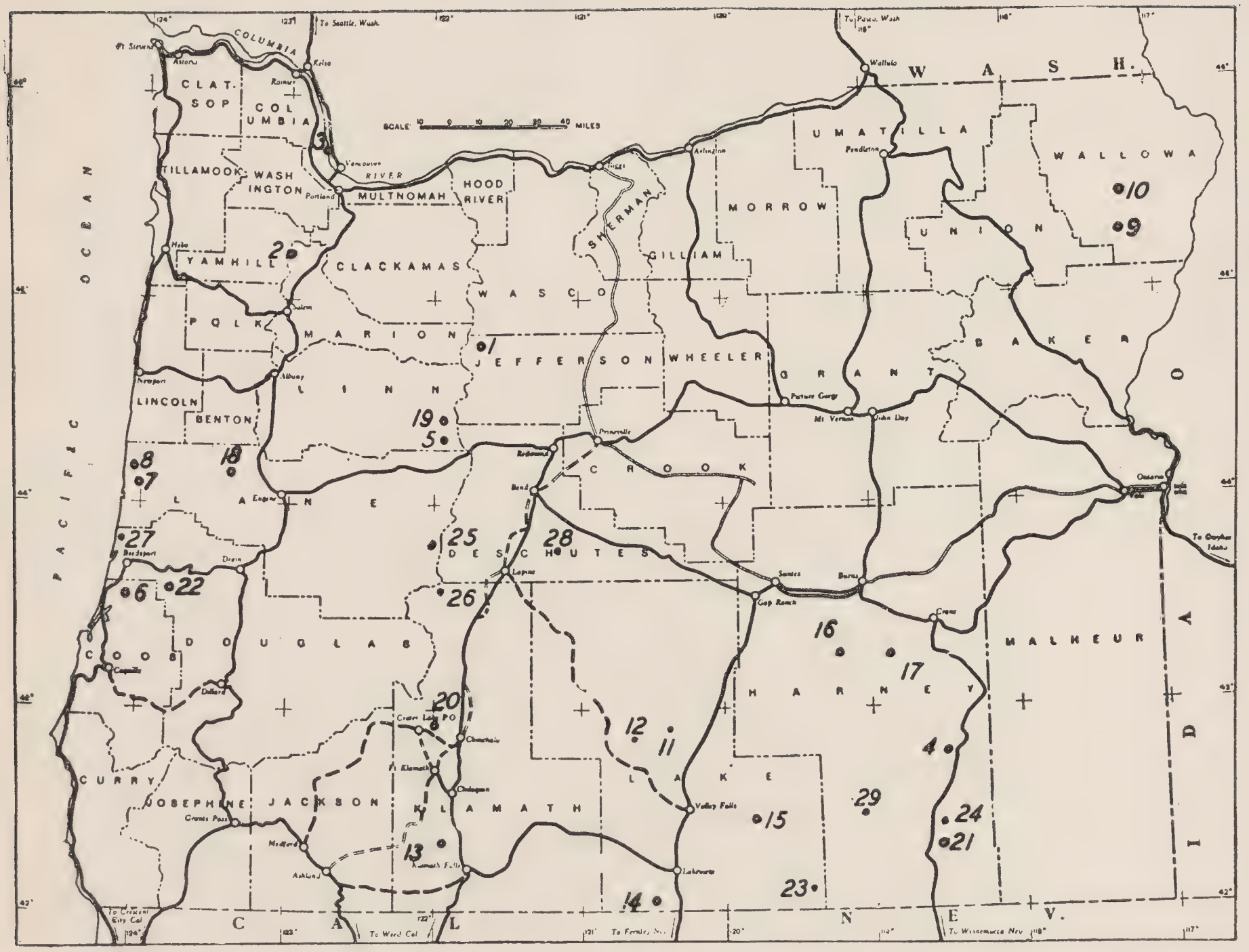

Figure 5. Location map of lakes mentioned in text.

1. Lakes around Ollalie Butte.
2. Horseshoe Lake.
3. Flood Plain or "Saucer" Lakes along the Columbia.
4. Mann Lake.
5. Plunge Pool beneath Lower Falls of McKenzie.
6. Tenmile Lake.
7. Mercer Lake.
8. Lily Lake.
9. Aneroid Lake.
10. Wallowa Lake.
11. Abert Lake.
12. Summer Lake.
13. Upper Klamath Lake.
14. Goose Lake.
15. Warner Lakes.
16. Harney Lake.
17. Malheur Lake.
18. Triangle Lake.
19. Clear Lake.
20. Crater Lake.
21. Borax Lake.
22. Loon Lake.
23. Guano Lake.
24. Alvord Lake.
25. Waldo Lake.
26. Odell Lake.
27. Tahkenitch Lake.
28. Paulina Lake.
29. Catlow Valley.

enclosed on both sides by infacing escarpments. The Klamath Lakes occupy such a **graben,** as do also the lakes of Guano, Catlow, and Alvord valleys.

The Klamath graben is the only one of these tectonic basins having exterior drainage. Upper Klamath Lake spreads nearly 25 miles in length and its outlet joins that of Lower Klamath Lake, lying partly in California, to feed the Klamath River, an antecedent stream which has cut a gorge westward through the Cascades. On the east edge of Upper Klamath Lake the fresh appearing escarpments of Plum Ridge and Modoc escarpment indicate that the faulting has been fairly recent. A recent fault plane with slickensides and striations can be seen at Modoc Point directly on the highway.

Other Lakes of Southeastern Oregon.

The lakes of Alvord Valley are singular enough to deserve particular mention. The widest part of the valley is occupied by the Alvord Desert (really a playa), while to the south is a smaller playa lake, Alvord Lake, fed by Trout Creek in the spring and early summer. A continuously flowing hot spring keeps a small portion of the lake filled with water even in the driest part of the year. North of Alvord Desert the valley narrows to about two miles across, and here the meeting of alluvial material carried toward the center of the valley by streams from the enclosing escarpments has formed the barriers for a number of small playa lakes. Typical of these are Mann Lake and Juniper Lake, both of which were once much larger, as indicated by old shorelines much higher than the present lakes.

Before being blocked by a recent lava flow the Harney Basin drained to the Pacific by way of the Malheur, Snake, and Columbia Rivers. The Harney Basin with its chief lakes, Harney Lake and Malheur Lake, has a semi-arid climate and interior drainage comparable to the basins immediately south of it, but the interior drainage of the Harney Basin is due to obstruction by a lava flow rather than to the faulting typical of the Great Basin area. According to Russell:[11] "The portion of the former channel of Malheur River now floored with a sheet of recent lava is about six miles north of Mule and leads from the broad basin of Malheur Lake eastward to Camp Creek," which is the southernmost tributary of Malheur River. In 1902 Russell estimated the surface of the lava dam to be only 10 or 15 feet above the normal lake level. Though formerly composing about a third of the drainage area of the Malheur River, the basin does not have sufficient rainfall to raise the lake level to a point where it will overflow the obstructing lava. A slight increase in the depth of the lakes greatly increases their areal extent and amount of surface exposed to evaporation.

Malheur Lake's flat bottom is seldom covered with more than 10 feet of water in its deepest part. Its maximum extent is about 23 miles by 5 or 6, and it is generally much smaller. The lake is fed by Silvies River, which drains the northeast portion of the basin, and the Donner and Blitzen River which receives part of the melted snows of Steens Mountain.

Harney Lake is roughly circular in shape and averages about 10 miles in diameter during the wet part of the year. During periods of high water the two lakes are connected at The Narrows, through which water from Malheur Lake flows to Harney Lake. According to information which Russell was able to gather, the channel called The Narrows was created in 1877 when farmers cut a furrow in the gravel embankment which formerly separated the two bodies of water. A channel was soon eroded by the flow of water. Since the flow is from Malheur Lake

into the deeper Harney Lake the water of the latter has the greater salinity.

Seasonal and yearly fluctuations in size are very great even among the larger lakes of southeastern Oregon. The lakes are in nearly every case exceedingly shallow, and hence having a high percentage of their volume exposed to evaporation at the surface, are sensitive to even slight changes in precipitation or evaporation. Extremes in both high water and low water have been observed since settlement of the area. The senior author crossed the dry bed of Harney Lake in 1923 in a car. In latter years there has been some return to former conditions.

Russell states that in 1881 Goose Lake was reported to have overflowed southward to the Pit River during a severe gale from the north. After traversing the area in 1882 he reported that none of the larger lakes had been known to become dry, but that during a succession of arid seasons they would unquestionably evaporate completely. Since that time some of the lakes have disappeared completely in several such dry periods. The most recent of these reached a climax in 1931, and another recent period, 1924-1926, was exceptionally dry.

The fluctuations of Goose Lake* are quite characteristic of the lakes of the area and of additional interest because of historical connections. The dry floor of Goose Lake in 1926 revealed wagon tracks which were part of an old emigrant road leading westward from Lassen Valley and Willow (Fandango) Valley. T. W. Symons reported tracing the old road from Lassen Valley to the lake in 1877. Goose Lake again evaporated to dryness in 1931.

Thorn Lake. Thorn Lake is, except in wet years, a dry lake bed about one quarter mile in diameter in central Oregon. At times in the past during exceptionally wet years water from Silver Lake has overflowed into this basin.

Although Thorn Lake has been bone dry for several years past and should ordinarily be classed as a playa lake, i e. merely a dry lake bed, it is of special interest because of some alleged ruins of a "buried city" in its bed. The senior author examined this site some years ago in the company of the late Colonel Wm. Hanley of Burns and Phil Brogan of Bend. It turned out on our investigation that the supposed walls of the "city" were nothing more nor less than some very irregular clastic dikes formed by sediments which had sifted into large cracks and become hardened. Later the softer lake silt had partially blown away leaving these standing up from the bottom of the basin from a few inches to a foot or more, resembling very crude walls, but so irregular as to pattern and thickness as to preclude the possibility of their ever having been of human design.

Playa Lakes. Further mention should be made of the many playas, particularly in Eastern Oregon. These are for the most part confined to the south-central portion of the state in the semi-arid region which is the upper end of the Great Basin region of the United States. These lakes, which are usually indicated in blue on the general commercial maps, have been for some years past quite dried up. With the return of greater precipitation within the last two years, some of these have been found to contain a small amount of water. They have unquestionably been dry and wet alternately throughout the centuries. From about 1920 to 1935 many of these lake basins were absolutely dry. Two particular examples which should be mentioned are Thorn Lake, already referred to, which used

*Steamboats came to dock just three miles below (south) of the town of Lakeview in 1915. In 1939 the waters of this lake have receded many miles to the south of this point.

to receive the overflow water from Silver Lake; one of the writers some years ago was camped in the bottom of this lake basin, and found it absolutely dry, in fact it was quite dusty. Fossil Lake is another one which is out on the high desert, and is a favorite hunting ground for the fossil hunter. Alvord Lake is one of the largest of these playas, some thirty or forty miles in length, and with a hard compact surface which makes an excellent speedway for the automobile. These basins are for the most part quite shallow, and it would take relatively little precipitation to cover their surfaces to a considerable area.

Prof. Ira S. Allison, Oregon State College, spent a considerable part of the past summer (1939) in mapping the shorelines of several of these former lakes, especially the one in Fort Rock Valley. His final report will be very welcome.

Lakes Impounded by a Minor Fault.

An Oregon lake which may be due to minor faults is Triangle Lake, a few miles west of the Coast Range divide on the highway (No. 36) between Eugene and Florence. It is a triangular shaped lake occupying the junction of tributary stream valleys; its outlet, Lake Creek, is a tributary of the Siuslaw River. Though conclusive evidence of faulting is lacking, several features tend toward this explanation: The greatest depth of the lake (about 100 feet) is along its western edge which is where the outlet occurs, the presence of submerged reefs (in the lake bottom) of sandstone identical with those which cause the rapids in the channel of the outlet, and the igneous intrusion thought by some to have caused the lake does not extend entirely across the mouth of the lake. However, heating near the contact with the intrusion may have increased the resistance of the sandstone to erosion by outflowing waters.

The size of Triangle Lake has been greatly diminished by the infilling of sediment and also by lowering of the outlet. The latter has recently been modified through the installation of a hydroelectric plant below the lake.

Lava Dammed Lakes.

Clear Lake is an excellent example of a lava-dammed lake. A small portion of the upper McKenzie Valley has been dammed by a flow of "aa" lava which serves as the barrier for Clear Lake at an elevation of 2001 feet. The flow provided a dam nearly 200 feet in height; the lake has a reported maximum depth of 172 feet. Surplus water overflows the dam and also leaks through it by way of several sink holes. The porosity of the upper part of the dam makes it impractical as a possible storage reservoir.

A particularly interesting feature of Clear Lake is the submerged forest which it has preserved beneath its surface. The trees which were growing in the valley at the time of the flow are still standing in their original upright position, and will probably remain intact for a considerable time, due to the quiet of the lake waters and the protective nature of the cold water and deposit of ooze which is accumulating on the lake bottom and around the tree trunks (Stearns).[17]

The state of preservation of the submerged forest and the slight erosion of the outlet are factors which point to the recency of the flow of lava responsible for Clear Lake. The flow took place sufficiently long ago, however, to permit a present growth of small forest trees. No accurate estimate has yet been made of the time that has elapsed since this submergence occurred, but it seems probable that it occurred not more than 500 years ago.

The Harney Basin formerly drained to the Pacific Ocean, but a recent lava flow cuts off its outlet through the Malheur River. The present lakes of the

basin are discussed with the other lakes of southeastern Oregon.

About 15 miles to the northwest of the town of Jordan Valley are some lakes which are due to the choking of Cow Creek Valley by a number of recent lava flows. The flows issued from the Jordan Craters which are aligned in a north-south direction a little to the west of Cow Creek. The largest and most characteristic of these Cow Creek lakes is the farthest north of the series dammed by the latest lava flow from the Jordan Craters. The flow filled the channel made by the stream in cutting through an earlier flow. Russell gives the following description of the lake. "The lava forms a dam, above which a lake about four miles long has been caused to form. The lake extends into lateral valleys so as to have an irregular outline, but on the average is perhaps half a mile wide. During high water stages it overflows across basalt and supplies other lakes to the south." Like the other lakes of this portion of Oregon it is lowered greatly during the summer months. Around its border large areas of naturally irrigated grass make an excellent supply of hay.

South of the Jordan Craters and east of Crooked Creek a lava flow from the Bowden Crater formed a lake that has since been drained by the downcutting of its outlet. Lakes of a similar origin, presumably were formed in the Deschutes River area during late Pliocene or early Pleistocene time and were responsible for the fresh-water diatomite deposits which occur there.

Crater Lakes.

Crater Lake invites the special attention of both geologist and tourist; besides providing a controversy for those who would explain its origin it has come to be recognized as one of the world's foremost scenic attractions.

This lake as is well-known to many people is situated in the crater of a prehistoric mountain posthumously named Mt. Mazama. It is approximately 21 miles in circumference, just under 2000 feet deep and its surface is about 6100 feet above sea level. It is located on the crest of the Cascades 75 miles northeast of Medford, and is a National Park. The photographs which make up the frontispiece show the general features of the lake.

In the summer of 1886 C. E. Dutton, with the aid of some men detailed from the troops at Vancouver barracks, lowered boats into Crater Lake to take soundings and study the slopes of the crater. He was surprised to record the great depth of 1996 feet, without the added correction for stretching of the wire. At this time also the first topographic map of the area was made. In his U. S. G. S. report at the end of the year Dutton described the depression as being comparable in characteristic features and origin to "the calderas of Kilauea, Mauna Loa, and Haleakala, in the Hawaiian Islands; the Volcan de Taal, in the Philippines; and the large calderas of Central America."

The water level of Crater Lake shows slight seasonal variations and also differs one year from the next, but it is in the main gradually becoming lower than the levels of previous recordings. The senior author has on several occasions compared the recent levels with that of the scale painted on a rock in Eagle Cove by Diller in 1901 when he re-established the earlier gage level which was set up by the Mazamas in 1896. The water level in 1935 was recorded as 12.22 feet below the "Diller zero", indicating a drop of 16.22 feet from the level recorded by the Mazamas in 1896 when they established the zero of their scale 4 feet beneath the lake's surface.

Early detailed geologic and petrographic work was done in the Crater Lake area by Diller and Patton respectively, their combined work being published in 1902. Diller believed the

evidence to show that the former mountain was destroyed and the "caldera" formed by subsidence. He cited the lack of fragmental material and the presence of "backflows" as evidence for the subsidence theory. However, Diller as well as Dutton recognized the lack of conclusive evidence of subsidence even though they both favored the theory as the most likely means of explanation.

For a long time the early theory of Diller with regard to the origin of Crater Lake has been questioned. Even his associate, Dutton, raised serious objections to the collapse theory. In 1934 and '35 Carl Swartzlow and W. D. Smith, at that time serving as ranger naturalists at Crater Lake, carried on some investigations which led them to the belief that simple collapse was not sufficient to explain what had transpired at this place. The evidence which they were able to obtain seemed to indicate that there was at least one and perhaps several explosions of Krakatoan magnitude, and in a paper published in the bulletin of the Geological Society of America they stated their case. Recently Howel Williams, vulcanologist at the University of California, has made investigations and has come to the conclusion that Diller's explanation was not adequate nor was the explosion theory alone correct, but that quite likely there was a combination of the two--explosion followed by collapse. While Howel Williams' conclusions have not been published, in brief he believes it likely that following an explosion of Mount Mazama, great quantities of frothy magma poured out of the mountain side and overflowed onto the low lands. As a result of the extrusion of the pumice the upper part of the mountain became weaker and eventually the top part collapsed and was engulfed in the huge caldera produced by the outpouring of ash and molten rock thus forming the crater as we find it today.

Newberry Craters.

Two picturesque lakes lie in the well-wooded cauldera of the Newberry volcano, about 35 miles east of the Cascade Mountains and about 16 miles off the Dalles-California highway, south of Bend. The Newberry volcano is circular in form, with a diameter of about twenty miles, and rises about 4000 feet above the lava plateau on which it rests.

Paulina Lake is the larger of the two lakes which occupy the depression. It is approximately two miles long and a mile and a half wide and has an elevation of 6331 feet. It is also the deeper of the two lakes, most of it being between 200 and 230 feet deep. East Lake is slightly shallower than Paulina Lake and is also forty feet higher. Consequently, water seeps through the porous volcanic rocks from East Lake to Paulina Lake. Recent extrusives occur between the lakes and scattered over much of the floor of the cauldera as well as on the outer slopes of the volcano.

Williams suggests that the removal of the upper part of the volcano is best explained as being accomplished by collapse and peripheral, concentric faulting. In contrast with Russell's much earlier explanation Williams points out that glacial erosion has played a minor part in modifying the cauldera.

A lake also lies in the small crater at the top of the South Sister, serving as a scenic reward to the hikers who climb the peak.

Hot Spring Lakes.

There is still another kind of lake in our state that we should take note of, namely the various so-called hot lakes. There are several of these, but the present writers have personal knowledge of three in particular: Hot Lake, Borax Lake, and Hunter's Hot Spring Lake.

Hot Lake is situated nine miles southeast of La Grande on the Oregon Trail

Highway in the Blue Mountain country or north-eastern Oregon. The "lake" is really an artificial reservoir on the bank of which is an important hotel. The boiling spring water which feeds the lake (two closely connected reservoirs) and the hotel has an estimated flow of a million gallons of boiling water per day. The temperature of the "lake", however, varies even in a single day, due to local wind directions and temperatures, and changes a great deal from summer to winter. The mineral content of the water is largely "sulphides of calcium, magnesium and sodium, and some aluminum salts and carbonates."

Hunter's Lake is located about three miles north of Lakeview and is the overflow of a small geyser-like artesian well, which was brought in some years ago as the result of boring for water by C. E. Williams.

Borax Lake is situated in the top of a small dome of saline deposits just south of Alvord desert in the Steens Mountain country of southeastern Oregon. Borax is being deposited from these waters at the present time and thirty or forty years ago there was considerable production of borax from this place.

All these lakes are little more than ponds in size and are due, in all probability, to vulcanism—that is to say, ground waters coming in contact with hot rocks at depth, and coming to the surface along well-defined faults in the crust. Of course there may be other possible causes for the presence of these hot waters, such as radio-active minerals, chemical reaction between minerals in which heat is given off, but of these we cannot be sure since data are lacking. In a region which in comparatively recent geological periods was active in volcanic manifestations it is reasonable to attribute these hot waters to causes connected with vulcanism.

Landslide Lakes.

Landslide lakes are not very common in Oregon, but there are in the state some lakes of this origin which deserve special mention: Loon Lake in the Coast Range, Dog Lake, west of Lakeview, and small slide lakes in the Klamath Mountains serpentine areas. There is also a possibility of small landslide lakes on the Oregon side of the Columbia River similar in origin to those of the Washington side, Trout Lake and the Blue Lakes among them, which occupy depressions in the material which slid from Table Mountain and Red Bluffs. Moose Lake in the Willamette Forest area is also a slide lake.

Loon Lake occupies part of the valley cut in thick sandstone and thinner shale beds by Mill Creek, which drains into the Umpqua River a few miles below Scottsburg. Because of the resistant sandstone the valley is in many places canyon-shaped; the high cliff faces of sandstone outcrops suggest how easy it would be for a rock slide to fill in the valley below. Leaving highway No. 33 at the Mill Creek bridge one may follow the narrow, crooked valley upstream, over about ten miles of fairly good road, to Loon Lake. The sides of the valley, and the slide material as well, are heavily forested and nearly obscure the evidence of the slide which is, however, apparent from the irregular distribution of sandstone boulders near the bridge at the lake's outlet and those over which the stream cascades. The lake itself is quite irregular in outline and etxends up the valley about four miles.

Beaver Dam Lakes.

Beavers and beaver dams are not nearly as plentiful as they once were in the state, but it is probable that their habitation of mountain areas will be sufficiently encouraged by protection and restocking that they will again build numerous small dams. Beaver dams often serve as erosion checks and

minor flood control aids. However, in the areas where beavers have been exterminated or their numbers too greatly reduced, their lakes have reverted to meadows. A number or mountain meadows owe their existence to the filling in with sediment of lakes which were obstructed for a sufficient length of time by beaver dams.

Man-Made Lakes.

Man-made reservoirs are becoming of more and more importance in Oregon as well as in other regions. The storing of water behind man-made dams is serving increasingly for flood control, irrigation, power, game refuges, and for supplies of drinking water. Numerous reservoirs are distributed throughout the state and others are being added.

In the construction of these lake-like reservoirs care has been taken to insure the stability of the artificial barriers which hold the water back. Man-made dams are exposed to the same forces which attack natural barriers, including seepage, solution, erosion at the top of the dam, and pot hole action at the base, but fortunately no large reservoir dams have failed in Oregon, with resulting property damage and loss of life.

A map showing the locations of Oregon's numerous reservoirs is included in a publication by the State Planning Board, "Oregon's Wild Life Resource". A few of the important reservoirs are:

Bonneville Lake (Largest in Oregon)
Warm Springs Reservoir
Ochoco Reservoir
McKay Creek Reservoir
Owyhee Reservoir
Thompson Valley Reservoir
Bull Run Reservoir, etc.

The recently approved Willamette Valley Flood Control project calls for the creation of seven great reservoirs on the headwaters and tributaries of the Willamette River.

BIOLOGY OF OREGON LAKES

The types and communities of plant life in lakes offer a great deal of interest to the limnologist as well as to the layman who merely wishes to enjoy nature. A great variety of forms of life ranges from the familiar plant and animal life of the shore zone of lakes to the minute free swimming organisms of deep water. However, aside from some studies made by Brode at Crater Lake from 1934-36 and some surveys conducted by the Forest Service, very little in limnology has been done in Oregon if one is to judge from the meager literature.

The general nature of the flora or plant life of Oregon's coastal lakes has been mentioned in connection with peat formation. In addition, a chart of specific plants and their general distribution in the coastal lakes has been prepared for these pages by Mr. Henderson, Curator of the Herbarium of the University of Oregon. The chart (Fig. 4) includes all of the common lake and stream-dwelling plants of the coast area, with the exception of the lower forms of plant life, and their general distribution is averaged for many years of observation and collecting by Mr. Henderson. In the main, the long-stemmed grasses, reeds, and sedges of the shore gradually give way to hydrophytes (water plants) such as **Potomogeton** and **Myriophyllum** with floating leaves, and then to the plants which are entirely submerged, among which are **Najas** and **Isoetes.**

Crater Lake has a very special type of environment whose conditions are to say the least, unusual. Life in Crater Lake has been studied by G. Stanley Brode and published under the title, "The Denizens of Crater Lake", in Northwest Science for August, 1930 and hence will not be repeated here.

A recent Forest Service survey, conducted by Fred C. Ziesenhenne, of the lakes of the Willamette National Forest provides a great deal of interesting information concerning the plant and

Equisetum telmateia.....horsetail
Typha latifolia.....cat tail
Equisetum fluviatile.....horsetail
Scheuchzeria palustris.....a rush-like swamp plant
Isoetes bolanderi.....quillwort
Sparganium augustifolium.....bur reed
Sagittaria latifolia.....shallow water tuber (wapato)
Ruppia maritima (in brackish and salt water).....a submersed herb
Potamogeton epihydrus.....a pondweed
Isoetes piperi.....quillwort
Potamogeton natans.....pondweed
Potamogeton pusillus.....pondweed
Potamogeton amplifolius.....pondweed
Potamogeton crispus.....pondweed
Potamogeton richardsonii.....pondweed
Potamogeton pectinatus.....pondweed
Zannichellia palustris.....horned pondweed
Najas marina.....submersed herb of pondweed family
Isoetes lacustris.....quillwort
Isoetes occidentalis.....quillwort
Brasenia peltata.....watershield
Brasenia schreberi.....watershield
Nymphaea polysepala.....water-lily
Hydrocotyle (Several sp.).....parsley family (found in mud and shallow water)
Myriophyllum (2 species).....milfoil
Ranunculus aquatilis.....water buttercup
Juncus torreyi (occasionally).....a rush
Lemna (all species).....duckweeds
Carex vesicaria.....a sedge
Beckmannia erucaeformis.....a grass
Scirpus validus.....a tule
Alisma plantage.....water-plantain

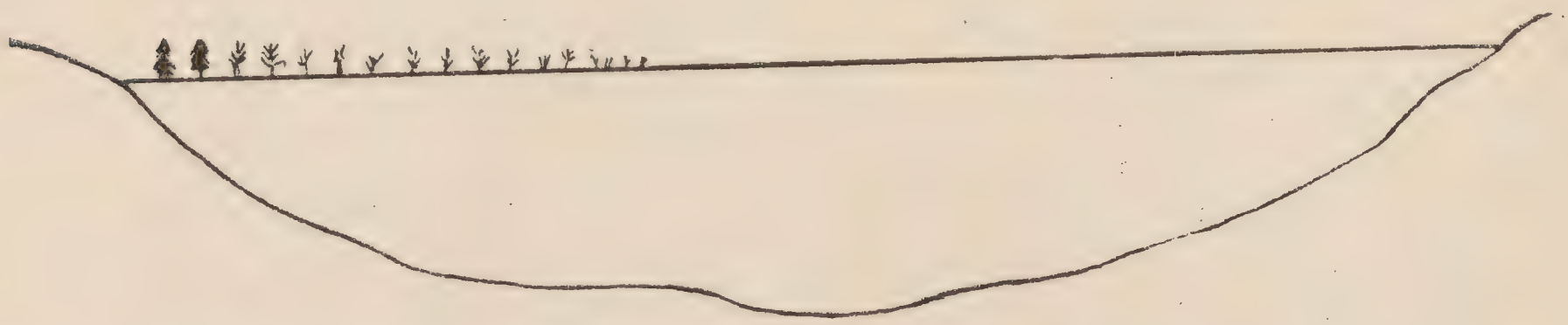

Fig. 4. Diagram illustrating plant zoning in a typical Oregon Coast lake. (After Henderson and Detling.)

animal life of a large number of Oregon's mountain lakes. The information obtained from the survey is particularly important in regard to the scientific stocking of the lakes with fish and fish food. Of the wealth of material contained in the report only a small portion will be mentioned here.

It was found that only 20% of the 252 lakes surveyed had outlets and inlets providing spawning gravel for the natural propagation of the fish of the lakes. Other physical factors such as the need for small dams were noted, and a number of lake construction improvements which would aid in stabilizing the dependent plant and animal life were recommended.

The fauna or animal life was found to vary greatly in the different lakes of the Willamette Forest area surveyed by Ziesenhenne, however, some of the genera and species are quite widespread. Of the free-swimming fauna the most common copepods are several species of **Diaptomus** and a single species, **Epischura nevadensis**; the most widely distributed of water fleas are **Holopedium, Daphnia, Bosmina,** Polyphemus, and **Diaphanosoma**; the free-swimming insect larvae of **Corethra** and **Chaoborus** are found; the most common rotifer is **Keratella cochlearis;** mastigophra (flagellate protozoa) Ceratium and Dinobryon are present in a very small percentage of the southeastern lakes as are representatives both of blue-green algae and fresh water algae.

Plants associated with the lakes of the area were collected by Ziesenhenne and identified by Dr. Peck, of Willamette University.

Of the lakes of southeastern Oregon the dominant biological factor in most cases is their salinity, resulting in the exclusion of many forms of life. The typical features are very well described by Russell in his reference to Summer and Abert lakes: "Although both Summer and Abert lakes are alkaline solutions, with shores as barren and desolate as the borders of the Dead Sea, yet they have many features that are attractive and picturesque, and furnish a striking contrast to the forest-bordered lakes of humid climes." He mentions among other things that their waters "are so strongly charged with salts that they are uninhabited by fish, but swarm with millions of small crustaceans of the genus **Artemia,** known commonly as 'brineshrimps.'" A typical plant of the white, salt-encrusted playas of the area is the small but hardy Salicornia.

ECONOMIC IMPORTANCE OF LAKES

There are nearly a dozen different economic aspects of lakes which we shall now enumerate with examples. Natural lakes and man-made lakes are very important to furnish water for irrigation and for domestic use in cities (such as Portland's Bull Run Lake). Lake Wallowa is perhaps the finest example of this use in Oregon. The Wallowa Valley is exceedingly fortunate in having this almost ideal setup for water for such uses. The supply is plentiful, constantly being renewed, relatively pure and cold. Incidentally this lake is one of the finest scenic features of a state very replete with fine scenery.

While we fish in the ocean and the rivers, the bulk of the sport-fishing in this state is probably done in the quiet waters of the hundreds of lakes, which type of fishing has many advantages over the other two.

In the category of scenery, our lakes probably hold first place; certainly one of them, Crater Lake, does. As scenery is fast coming to be our premier economic resource, the part that lakes play in this should not be minimized. The monetary returns from the exploitation of the scenery of this lake alone runs into the hundreds of thousands of dollars, but other returns less tangible are

even greater, and cannot be measured in dollars.

Many of our lakes, two notably, Malheur and Harney in Central Oregon, are bird refuges. The importance of such wild life refuges in maintaining the balance of nature has been dwelt upon by the Government biologists so often that we need not repeat their statements here.

Several lakes in that part of the Great Basin which lies in Oregon are exceedingly important as potential sources of various salines such as sodium bicarbonate, borax, and common salt. At the present time there is no commercial exploitation of these deposits, but some day they will doubtless be utilized.

Former pre-historic (Pliocene and Pleistocene) lakes were responsible for the accumulation of considerable amounts of diatomite which have been used commercially to a limited extent.

Many small coastal dune lakes and ponds have in them heavy growths of sphagnum moss which during the World War was used extensively for surgical dressing, because of its high absorption property.

Man-made lakes or reservoirs are being made for the storage of flood waters and for power. These of course will have a very direct economic value. And so we might conceivably find other economic uses and values for lakes, but these are the most important at the present time. In this connection we should not overlook the many small dams and storage ponds created by the industrious little beavers, which are of considerable value in the conservation of the soil.

ORIGIN OF LAKE NAMES

The origin of the names given lakes are often of considerable interest, both biologic, genetic, and historical.

Lakes in Oregon have been named by their size (Big, Little), by their color (Clear, Dark, Green, Blue, Silver), by their composition (Mud, Borax, Salt, Alkali), by their origin (Moraine, Crater, Lava, Notch), by their shape (Square, Round, Triangle, Long, Dumbell, Horseshoe, Crescent). Animal names are very common (Bear, Goose, Elk, Mink, Horse, Loon, Duck, Mallard, Deer, Buck, Dog, Trout, Moose, Gander, Otter, Eel, Fish, Frog, etc.) as are names from plants (Wood, Pine, Olive, Thorn, Cedar, Lily, Tule).

Indian names are very common (Oswego, Klamath, Olallie, Mowitch, Stiltcoos, Takanith, Wohink, Kiwa, Wahanna, Timpanogas, Calamut, Cultus, Winopee, etc.) and names of early Oregon settlers and pioneers appear frequently.

"Lost" and "Bottomless" Lakes.

There are several lakes designated by the name of "Lost Lake". These names probably arise from the fact that the early inhabitants of the state had difficulty in finding them again. Lakes do not become lost until they become extinct from one cause or another.

A common statement about some lakes, especially Crater Lake and Lake Wallowa is that they are "bottomless". Of course if they were bottomless the water would run out! What people mean when they make such a statement is that the bottom has not yet been found. Again this statement is erroneous, because in the case of both of these lakes the bottom has been found wherever the sounding has been thoroughly carried out. Wallowa is, as stated in an earlier paragraph, not only not bottomless, but quite shallow compared with many other lakes of its size. The bottom of Crater Lake is more accurately mapped than the surface of many townships of the state.

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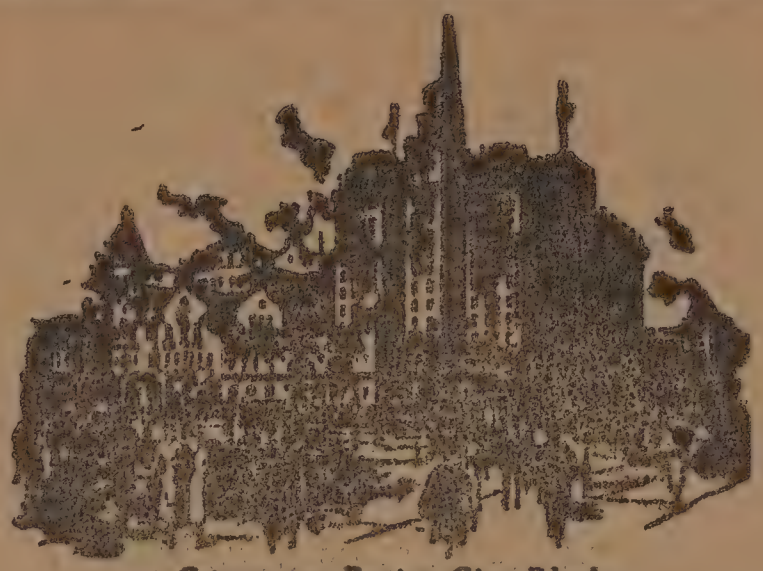

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Sixteenth Annual Meeting Northwest Scientific Association

The sixteenth annual meeting of the Northwest Scientific Association was held December 27-28 in the Davenport Hotel, Spokane, E. J. Gaines, of the State College of Washington, Pullman, presiding.

Eight sections had program meetings at which 61 papers were read. A feature of the Geology-Geography section was a symposium on the "Relief Features of the Columbia Plateau," in which the original arguments were presented by Dr. O. W. Freeman, for Washington; Dr. Warren D. Smith, for Oregon, and Dr. Alfred L. Anderson, for Idaho, and from which spirited discussion resulted.

The Social Science section held a short one-day meeting, then adjourned to permit joint sessions with the Pacific Coast Economic Association which held its meetings December 27, 28, and 29 at Pullman and Moscow. The only regular session mission from the program this year was the Psychology and Education group whose members feit that conflict of other educational meetings held at the same time or in the spring and fall precluded their active participation in the program.

Botany-Zoology had the largest program with 12 papers, followed by Geology with 11 regular papers aside from the Symposium. At the other end of the list were Social Science and Engineering with three papers each.

The annual dinner was held Wednesday evening, December 27, in the Elizabethan Rooms. J. H. Ramskill of Montana State, retiring president, spoke on "Recollections of Burns". Reports from the recipients of research grants were also heard.

The first general session opened with an address, "Economic Order and Democracy" by Dr. Arthur G. Coons, Professor of Economics, the Graduate School, Claremont Colleges, Claremont, California.

Harold E. Abbott, landscape architect and assistant superintendent of parks for the city of Spokane, spoke on "Conservation and the Landscape Architect" at the joint meeting with the Associated Engineers, Wednesday noon.

Thursday morning Dr. Karl L. Kauf-

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man, Assistant Professor of Pharmacy. State College of Washington, addressed the Sigma Xi breakfast group on "The Assay of Certain Alkaloidal Drugs and Their Preparations."

There were 155 officially registered for the meetings and sessions, as well as nearly 100 auditor visitors who did not register as members. Of this registration list 57 were new members. Total membership remains at nearly 500 with over 300 library subscriptions and exchanges.

Officers for 1940 includes: F. W. Gail, University of Idaho, Moscow, president; J. H. Christ, Soil Conservation Service, Spokane, vice-president; and W. B. Merriam, Eastern Washington College of Education, Cheney, secretary-treasurer. O. W. Freeman, Cheney, remains as Editor of Northwest Science.

John Ehrlich, University of Idaho, was named as councilor for a full five-year term succeeding his temporary one-year fill-in appointment. Three-year trustees include: J. Warren Severy, Montana State University; W. A. Rockie, Soil Conservation Service, Spokane. One-year trustees include: Thomas Large, Lewis and Clark High School, Spokane; H. T. Gisborne, Rocky Mountain Experiment Station, Missoula; and Ernest McCulloch, State College of Washington.

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An overcoat belonging to J. G. McMacken of Lewis and Clark High School, was taken while he was in attendance at the Geology section of the Association, at the December meeting in the Davenport Hotel. If some member of the Association traded coats accidentally, Mr. McMacken would appreciate the returning of his coat.

Mimeographed indexes for volumes 11, 12, and 13 of Northwest Science have been prepared by Mr. Leonard Thorp, Assistant Librarian, Eastern Washington College of Education. Copies of these will be sent gratis to members requesting same of the editor, Dr. O. W. Freeman, at Cheney, Washington.

Conservation and the Landscape Architect

By HAROLD T. ABBOTT
Landscape Architect, Spokane, Wash.

Conservation is a practice which has become one of the most severely criticized and abused in our present day life. Its true meaning and value as the solution for most of our economic ills is appreciated only by the smallest percentage of our population. Conservation, in the minds of many people, is merely a movement sponsored by a few sentimental-minded lovers of nature who are afraid the more practical-minded will use up all the earth's resources. To discuss the question of conservation with the average person is a most disheartening experience, for we are apt to discover that such a subject stimulates very little interest, in fact it gives rise to every evidence of boredom.

In the past, problems of the conservationist have been limited, unfortunately, to the setting aside for future generations of areas which are distinguished by some outstanding scenery or natural wonder. For instance, for many years after the establishment of Yellowstone Park in 1872 as a conservation act, the American people believed that such methods of setting aside regions of natural beauty were the sole concern of conservation groups. But as time went on the more thoughtful citizens realized that conservation was a much greater thing than the mere setting aside of remote beauty spots and certain freaks of nature. The tremendous growth of our cities with their constant demands for more and more raw materials, the keen competition to gain first place among the producers of these raw materials, and wasteful methods associated with this production added new problems for the consideration of farseeing men and women, and conservation groups again were the champions of the movement for the prevention of waste. And so it has been that the battle between the uncontrolled and wasteful producer and the exponents of intelligent use of the earth's wealth has been waged. However, the issue is one which involves every American. The attitude which is disgracefully common in this country at the present time is that the question of providing natural resources for future generations is in the hands of the scientists and that when we run short of coal, of wood, of oil or the metallic ores science will come to the rescue and provide substitutes. The past has taught us a bitter lesson and scientists themselves assures us that not even with them are all things possible. Greed, selfishness, indifference towards waste and the shirking of stewardship as regards the resources of nature are among the greatest curses of the American people and the answers to most of our troubles. We can have little regard for the individual who says "this is a free country, I'll let the other fellow do as he pleases and I'll do as I please. And why should I concern myself about what might happen in a hundred years? Why borrow trouble? Then too, you know what they say about crossing bridges?"

"Originating in the spectacle of waste and defilement," says Lewis Mumford, "the conservation movement has tended to have a negative influence: it has sought to isolate wilderness areas from encroachment and it has endeavored to diminish waste and prevent damage."

Fortunately, this old conception of conservation has given place to a new, all-embracing opportunity for a higher plane of living in this present age and for great service to all future generations. This new conception is regional planning.

"Regional planning," Mr. Mumford continues, "is the conscious direction

and collective integration of all those activities which rest upon the use of the earth as site, as resource, as structure, as theatre."

He says, "the present task of regional planning is a more positive one: it seeks to bring the earth as a whole up to the highest pitch of perfection and appropriate use—not merely preserving the primeval, but extending the range of the garden, and introducing the deliberate culture of the landscape into every part of the open country."

Continuing, Mr. Mumford maintains, "the task of regional planning is to make the region ready to sustain the richest types of human culture and the fullest span of human life, offering a home to every type of character and disposition and human mood; creating and preserving objective fields of response to man's deeper subjective needs."

We see by Mr. Mumford's definition of the field of regional planning that the conservationist has widened his range of vision and taken upon himself a new responsibility far greater than was ever dreamed of at the turn of the century. We should begin to appreciate also that we do not "live by bread alone" and that most of our wealth cannot be computed in terms of the latest market values. The various phases of conservation have until very recently been carried on by purely independent groups, each interested in its own program, somewhat envious of prominence given any one of the other groups, and each restricted by the name under which it has worked. It is not necessary to mention here those groups which have been functioning so admirably in behalf of the preservation of certain natural resources for economical use. We are aware of the great contributions they have made. However, it is this more comprehensive work of regional planning as the embodiment of all phases of conservation which should be our first concern.

To illustrate how extensive our problem of conservation has become, we may consider the regional planning aspects of our national highway systems. In the development and control of our roadsides, this problem has presented itself most forcibly to us.

The history of the development of roadways in this country is one marked by abrupt changes influenced by the various inventions for speeding up transportation. From the days of the trail and the horseback rider to the improved roadways with room for two stages to pass conveniently and with easy grades to facilitate the hauling of heavy loads there was a long slow transition. But at the beginning of the present century with the advent of "horseless" carriages a rapid change commenced and up to the present day the demand has been for roads which will permit us to travel at ever increasing speeds. To meet these demands, much of the natural beauty as well as the permanence of the roadways themselves and the adjacent natural resources of economic value have been sacrificed. Latest studies by various states have shown that a vast majority of our roadways are far from being efficient from the scientific point of view and that the road pavement itself plays a relatively small part in the efficient design. In road building, the shortest distance between two points isn't always the straight line in spite of the fact that the highway engineer reduces his cuts and increases his fills. Jac Gubbels has said most aptly, "The road is not the shortest for the engineer unless it is the most easily constructed, or for the highway department unless it is the most economical to build and maintain. It is not the shortest for the driver unless it is the safest, or for the passenger if it is not interesting."

The public demands of which we

have made a brief remark have manifested themselves first in a desire for greater speed and the solution seems (according to concrete results) to be in the reducing of grades, widening of the road pavement, clearing the entire right of way, and the elimination of curves. However, the recent experiments conducted by the Texas State Highway Commission have shown us that earlier figures regarding accidents compiled in Connecticut are not just the unusual but the typical conditions on all our highways. Whether we call it "road focus" or "carelessness" we know that more accidents occur on straightaways than on curves and that the "flight" line with reduced grades is not necessarily the safest. The public does demand speed but it demands speed only with the guarantee of safety and comfort.

But the question will be raised as to the use of our highways and as to whether we shall turn an ear in the direction of those idealists who visualize the scientifically efficient roadside. According to the Bureau of Public Roads more than half of all the travel on our highway system is by tourists and other motorists driving for pleasure and for the enjoyment of the landscape. It is this large group of citizens who seek the efficient roadside but who do not know how it may be brought about. They are conscious of the fact that fine pavements have been laid with every technical skill available, but the mere laying of the pavement and the provision of a smoothly graded shoulder and gutter have not satisfied their desire for something more enduring. In other words the cross sections of our roads are still incomplete. Our roads are efficient in most instances as far as the gutters to the extent that we are apt to erect imaginary fences at those limits and consider our work finished. To the remainder of the right of way we cast a hasty glance, perhaps pick up the rubbish which has accumulated, and then breathe a prayer that nature will smile upon our work and cover the scarred landscape with her protective green mantle. But no such miracles reward us for our neglect of the roadside; rather, we are brought face to face with our error by not only being deprived of the rewards of nature but by witnessing the most ruthless destruction of our investment that nature could impose. Gubbels has pointed out most clearly in his recent treatise, "American Highways and Roadsides", that the incompleted highway is one of the greatest enemies of conservation and that even a completed highway is an obstruction laid through the landscape. The engineer cannot escape the forces of nature; he can only minimize them by conforming to the laws of the landscape. He must realize at the same time that it is sound economy to observe conservation policies and must demand that the right of way be developed as consistently and completely as the pavement itself.

During the last few years we have heard a great deal about "highway beautification," in fact the very combination of words has been used to the detriment of the well-intentioned advocates of the roadside garden. Roadside development as we are considering it here concerns the entire planning and construction of the roadway from the earliest conception of the project to the completed planting. According to the Joint Committee on Roadside Development of the American Association of State Highway Officials and the Highway Research Board, "Roadside development must conserve, enhance and effectively display the natural beauty of the landscape through which the highway passes as well as provide maximum safety, utility, economy and recreation facilities by means of proper location, design, construction and maintenance of the highway."

This statement by the Joint Commit-

tee is conclusive evidence that more and more recognition is being given to the value of collaboration of highway engineer and landscape architect. It is recognized that "what is planned well, looks well," that there must be beauty as well as utility if our investment is to pay the highest dividends. And it is the return on our investment which determines how successful we have been in combining this beauty and utility. The argument so commonly raised by so-called practical minds is that expenditures for wholly esthetic and recreational needs is like pouring water upon the sands of the desert—there seems to be nothing to show for it. However, we have learned from a few less practical minds that it isn't so far-fetched to pour water on the deserts after all. From what we have just considered as necessary for the protection of the highway investment we should be cheered to know that for a sum equivalent to the cost of one mile of improved highway more than thirty miles of improved highway plantings can be done. Moreover, there are definite financial returns from the increased valuations of proprty along the improved right of way. From studies made recently in the Union County Park System of New Jersey, it was found that over a seventeen year period, increased property values on areas adjacent to the county park lands increased between 250 and 630 per cent. According to W. R. Tracy, Engineer and Secretary of the Park Commission, "A comparative survey of the Union County Park System of all properties adjoining the 4,282 acres of county park lands would probably show that revenues on increased assessed valuations directly traceable to the development of the various parks more than pay for all the carrying charges on this five million dollar investment in recreation and beauty." The findings of Elizabeth and of Union County are not unusual. We see evidences in our own cities of similar increased valuations due entirely to the improvement of adjacent areas as beauty spots for various forms of recreation. The effect of well-designed roadsides on surrounding property values is comparable to that brought about by any other attractive outdoor areas and it becomes the duty of each highway commission as agents of the people to create every possible opportunity for increasing these land values.

How are we then to foster this new attitude of conserving natural beauty through regional planning? How are we to go about this new job of cutting maintenance costs through the consistent completion of the cross section? How may we as highway commissioners, highway engineers, landscape architects or laymen in the field of conservation—how may we aid in bringing about this improved condition?

In general, people are keenly appreciative of beauty and the destruction of recognized scenic features immediately gives rise to violent opposition on their part. Most people may not be conscious of the fact that attractive surroundings are as essential to their well-being as recreational activity, food, and clothing, but they are early to register praise and gratitude for beauty created for their benefit. Robert Moses of New York City, in commenting on the appreciation of the public, said recently, "Mean parks make mean people who are moved to trample, disfigure and destroy things which are ugly, inadequate and contemptible to begin with. People, generally, respect and care for good things and resent what is cheap, inadequate and shoddy. You can expect cooperation from the public in the care of parks and recreation grounds only if you give them the best; that is, if you give them something which is obviously suitable, adequate, durable, and perhaps a little imposing."

Having studied the reactions of peo

ple who have accustomed themselves to surroundings of ugliness, squalor, destruction and misery, and compared them with the reactions to surroundings of orderliness, beauty, efficiency, and joyousness, we are impressed with the importance of perception in cultivating a truly valuable character. The cult of perception is essential to every person who desires to understand the processes working about him, those opposing forces upon which all life is based, forces building up and tearing down. The practice of taking time for reflection and meditation has become a lost art, so that many sources of enjoyment are not open except to the man who will take the time for thought and consideration. Therefore, it becomes the obligation of each American to not only rekindle those fires of perception within himself but to prove by his outward acts that those fires actually burn.

There remains yet a problem which prevents this great program from being carried out in this country. It is a human problem and one which is as old as the races of mankind, namely the recognition of the true importance of human resources. The foregoing discussion has shown clearly, I believe, that the conservation of beauty is an important function of government, that the preservation of beauty is essential for the general welfare of the American people and that it is economy to plan on a large scale, keeping always in mind maximum utility with regard for beauty. In the words of Wilbur Simonson of the Bureau of Public Roads, "Fundamentally, roadside improvement is a problem of appearances in which beauty and ugliness are analyzed and separated." This undeniably stamps it as a fine art as well as an engineering consideration. It is significant to note that in the U. S. Civil Service Examination for "Conservationist" held in April, 1935, for the Forest Service the applicants who were found ineligible were inadequately prepared in the principles of Landscape Architecture. A further need for the trained planner was evidenced by the examinations for the various grades of Landscape Architect held by the Civil Service Commission in 1937. Most eastern states and some western states now have well established landscape departments with professionally trained men working in collaboration with highway engineers and architects in the interest of scientifically efficient roadside developments. It is acknowledged by the foremost highway designers that more desirable results would be obtained in the various states if the individual district offices had their own properly qualified landscape architects who have not only had training and experience in engineering but also in the designing of public areas for maximum use and beauty. A few additional dollars spent for proper planning in the office means conservation of our natural resources, maximum use of all developed lands, increased land valuations, reduced construction and maintenance costs, and considerably more opportunities for improving the general character of man's environment.

Finally, as we accept this challenge to plan consistently, broadly, and intelligently, let us not lose sight of our sense of values to the extent that we concern ourselves only with the pressure of today's needs. It is well for us to remember always the timely wisdom of Roberts Mann that "these things of nature that remain and are the only permanent, enduring things in a world of discorded change: the trees and the mountains and the prairie and the desert that have seen other civilizations rise to their peaks and fall to die, may hold in their beauty and their silence the deciding factors in the very existence of our democracy."

Some Forest-Soil Relationships

Contributions to the Ecology of the Big Bend Area of Washington:

II. Indicator Significance of the Natural Plant Communities in the Region of the Grand Coulee Irrigation Project

By R. F. DAUBENMIRE
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Conservation may be defined as the management of natural resources to give the maximum number of people the fullest benefits of every resource. Such an objective obviously necessitates a thorough understanding of these resources in order to plan their utilization in accordance with their potentialities. Improper administration of a resource may not only result in wasted investment, but the value of the resource itself may be greatly impaired, such as has been the case with the soils of the Dust Bowl area of the Great Plains.

The few undeveloped areas which still remain in the United States and its possessions offer a challenge to the abilities of man to practice what conservation principles he has learned by his past mistakes. The irrigation project which is being developed in the Big Bend area in Washington presents just such an opportunity.

Superficially it appears that we have a fairly level desert area which needs only water to convert it into a uniformly valuable agricultural region. Apparently all that is needed is to grid the area into tracts of 40 acres as is now planned, supply irrigation water, and let the success of the project rest entirely upon the diligence of the farmers. But nature has not endowed this area with uniform soil conditions, and farmers who settle tracts of good soil will prosper while their nabors may have a difficult time of finding subsistence on a tract of equal size and with the same amount of irrigation water. The question immediately arises as to whether or not there is some way of evaluating different tracts, some method of distinguishing those so relatively unsuited to agriculture that they will demand special preparation, and predicting which are suited to one group of crops and which to another. There is a practical answer to this question, and it is contained in the natural vegetation.

To the layman desert vegetation appears monotonous and perhaps confused, but the trained ecologist sees in the same region a pattern of communities each of which has its own very distinct environmental relations.

Nature has long been at work with plant life. It is probably safe to say that every square yard of soil surface in eastern Washington has at some time received at least one seed of practically every plant in this region. Therefore the fact that the vegetation is not uniform throughout this region cannot be due to all species not having had equal opportunity to migrate into every part of it, the heterogeneity must be attributed to a corresponding heterogeneity in environment which has allowed only certain plants to survive in each type of habitat. In the course of time the net effect of this selective action of the environmental variation is to produce more or less distinct plant communities on different habitat types. Wherever the same environmental complex is met, the same plant community is repeated. Wherever sand or alkali soils occur, their characteristic plant

communities are repeated. Such plant communities, developed through long periods of vegetational adjustment, clearly reflect the nature of the soils in the Big Bend region. Consequently, when the communities* are defined, and their indicator significance is worked out, we have a botanical yardstick to evaluate the characteristics of the soil in terms of plant growth. A fact which makes this practice especially applicable in Washington is that the natural vegetation has not yet been so greatly disturbed but that the area originally covered by each of the major plant communities can usually be recognized in the field.

Prior to the survey undertaken by the writer, no attempt had previously been made to classify and evaluate the indicator significance of the natural plant communities in the region of the Grand Coulee Irrigation Project, although good use has been made of this principle in other parts of the country. All parts of the Big Bend area have been studied in order to arrive at a classification of the natural plant communities, and to ascertain their soil characteristics.

All of the natural plant communities of any significance in this connection may be classified under one of the following five types:

I. Saltgrass Type.
II. Greasewood Type.
III. Hop-sage Type.
IV. Sagebrush Type.
V. Rabbitbrush Type.

I. Saltgrass Type. Nearly pure stands of saltgrass **(Distichlis stricta)** are well distributed over the Big Bend country. Wherever this type occurs it indicates (1) a harmful degree of salinity, and (2) a high water table for at least part of the year. The latter characteristic of these soils would signify that some provision for drainage must be made when irrigation water is applied, for such a degree of salinity cannot develop without a basin-like obstruction to drainage below the ground surface. Where drainage is feasible, these soils may be leached free of most of their alkali, and salt-tolerant crops such as sugar beets, clovers, alfalfa, etc., may be grown.

II. Greasewood Type. Soils with only slightly less alkali but with a lower water table are covered with greasewood **(Sarcobatus vermiculatus).** Herbaceous species of Atriplex, saltgrass and other halophytes commonly grow on the ground beneath these shrubs.

The difference between these soils and those covered by saltgrass is one of degree, although the appearance of the plant cover is greatly different. These soils should be more easily flushed to a suitable depth, so that their reclamation may be expected to require less investment.

III. Hop-sage Type. A stand of hopsage **(Grayia spinosa)** indicates definite though mild conditions of alkali. Here the salt content is not high enough to permit the dominance of greasewood, yet is high enough to prevent sagebrush from dominating the areas.

Around alkali basins the vegetation is frequently zoned with a saltgrass area on the wettest and saltiest soil, a zone of greasewood next, followed by hop-sage and then sagebrush. Mixtures of hopsage with sagebrush indicate slightly less alkali, while mixtures of hopsage with greasewood indicate slightly more alkali, than occurs in soils where the hop-sage occurs alone.

IV. Sagebrush Type. Fortunately for agriculture, a high percentage of the soils in the Big Bend country suppor

*The use of **plant communities** as indicators has been proven valid by numerous detailed studies, but the indicator value of **individual** specimens or even species is very doubtful. Furthermore, all statements in this paper refer to the **characteristic** habitats of each community. As in all biotic phenomena, there are exceptions to the rules.

stands of sagebrush **(Artemisia tridentata).** The presence of these can usually be taken to indicate a deep, porous, and fertile soil. This type occurs on soils ranging all the way from loessal silt-loams to alluvial gravel-loams.

On alluvial sandy soils sagebrush is frequently accompanied by bitterbrush **(Purshia tridentata).** The fertile orchard soils of the Wenatchee region appear to have been developed from such land, and similar alluvial terraces such as those near Pasco may be expected to have equal potentialities when they get water.

In certain localities the sagebrush country has been burned over to improve the grazing conditions. In such cases the appearance of charred stumps, seedlings, or the recollections of old residents may be used to ascertain the boundaries of the original stands.

V. Rabbitbrush Type. The most complex vegetation in the Big Bend area is that of the glacio-fluvial deposits and their dune derivatives. Clearly, in all the vegetation of the sandy soils, rabbitbrush **(Chrysothamnus nauseosus** and **C. viscidiflorus)** is the most ubiquitous. On the peculiar blackish dune sands just west of Neppel, bitterbrush is associated with rabbitbrush. Here and elsewhere there are occasional stands of needlegrass **(Stipa comata)** and Indian ricegrass **(Oryzopsis hymenoides).** All of these communities indicate sandy soil, but the differences in the environment which determine the dominance of one species or another are not evident. It is altogether quite possible that these variations in vegetation of the sandy soils reflects past disturbances rather than variation in soil.

Under cultivation all of these soils are susceptible to blowing, especially in winter, but if they are kept moist by irrigation, or covered with crops, or protected by windbreaks they will probably not be a hazard from this standpoint.

Good orchards have been maintained in the irrigated Yakima region on such sandy soils, in spite of their tendency to be infertile. It may prove that the application of fertilizer will yield economic return, especially after the first few years of cropping these soils. Most certainly these soils will have to be irrigated with the greatest care to prevent the leaching of fertility below the depth of plant roots.

In Conclusion.

Native vegetation represents the final outcome of the operation of ecologic factors which have influenced plants throughout centuries, and which are operating today not only on the remnants of the original flora, but on our crop plants as well. It seems clear that distinct vegetational differences are correlated with important soil variations in the Big Bend area, and consequently the various types of vegetation constitute a biologic measuring stick of every acre of soil. Different soil types require different preparations of the land, different amounts and methods of application of water, and will be more suited to certain crops than to others. The development of virgin land into irrigated farms is an expensive process, and we should take advantage of every bit of knowledge to insure the success of the operation.

Five key types of vegetation are designated and their indicator value discussed. It is recommended on a basis of this survey that as the area to be irrigated is divided into tracts, a map of the vegetation of each tract be sketched and kept on record. Such maps can be made by non-technical assistants after they are taught to recognize the important indicator types, and they should prove of very material value to anyone interested in getting the most good out of his land from the very start.

The Significance of Natural Erosion

By DR. L. C. WHEETING
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Erosion is a natural process which tends to produce a level land surface and with this surface—stability. In geological parlance, this process is known as peneplanation. Whenever a land surface is thrust up above the general level, it is subjected to erosive forces in an effort to bring it into line with its surroundings. In this process wind, and especially water, are dominant factors. This is beautifully illustrated by portions of the book "Seasoned Timber" by Dorothy Canfield, in which Professor Dewey, while pointing to a hollow in the granite of a mountain, which had been filled with water by recent showers, explains how the water, though soft and yielding and apparently strengthless, would in the end get the better of the hulking rock carcass of the mountain.

Natural erosion as a process is necessary and good. By this means the fertility of soils are constantly renewed But, like many other things, including motor cars, accelerated erosion is not good because it destroys what Nature, in its normal processes, intended to be useful. Let us examine this thought further.

Soil makes up a relatively thin shell on the outer surface of the Earth. It is produced by processes of rock weathering, followed by the incorporation of organic matter. Soil is produced only when organic life has invaded the rock pile. The character of the soil is determined, therefore, not alone by the nature of the parent rock from which it sprang, but also by the processes which produced it. The natural forces of climate not only determine what form of vegetation will inhabit the soil, but also what chemical processes will be active in its formation. In regions of sparse rainfall, solution processes are at a minimum and the products of rock decay tend to remain in the soil; while in regions of high rainfall, they are removed by leaching. In the first instance, alkaline soils are produced, and in the second case, acid soils develop. The rainfall also affects vegetative acidity and in regions of low rainfall, the amount of plant growth and the volume of plant residue remaining in the soil is low; while in regions of heavier rainfall, plant growth is vigorous and large amounts of organic matter are added to the soil. This leads to a more intense differentiation of soil layers in the wetter climate. The entire soil-formation process must be looked upon as a movement toward an equilibrium between climatic and vegetative forces on the one hand, and the resistance of surface of the earth on the other. It is strange that when equilibrium is reached, an unproductive soil is the result. Natural erosion is the process set up by Nature to forestall this unfortunate ending. By the process of removal of the old, worn-out soil materials, new and fertile mineral matter is constantly being exposed to weathering, and the results are wholly favorable, from the viewpoint of soil productivity and human welfare.

Imagine a perfectly flat earth, where no erosion could occur. The soil-formation processes would reach down into the land surface for several feet. The minerals would be broken apart physically and chemically, plants would remove the parts of them required for growth, and tie up this material in the form of plant products; excess rainfall would leach away the remainder to increase the salts of the sea, and eventually the entire soil would become infertile. Since weathering can proceed only to limited depths and root penetration

is also limited, eventually the completely flat world would become unable to support further plant life (as we know it), and with this destruction of plant life, our own existence would be impossible. How fortunate for us to live in a world with hills, mountains and valleys, with natural erosion constantly exposing new land surfaces on the uplands and periodically blanketing the lowlands with thin layers of fertile silt. The history of our World as indicated by rocks, shows that upheavals of the land surfaces have occurred throughout the ages. Thus, a provident Nature periodically resorts to face lifting to maintain her beauty.

It seems to be natural for the Earth to be covered with vegetation wherever climatic conditions will permit it. This contributes mightily to the stability of the land surfaces, through the binding effect of plant roots, the interference with the driving force of the rain, and through the development of high permeability and water-holding capacity of the soil as a result of the presence of organic residues. When this regulatory factor is removed from land surfaces, serious accelerated erosion often sweeps away the work of many years in a single hour. It is the work of the Soil Conservation Service to overcome this, and through a judicious return to vegetative controls, combined with the necessities of crop production for profit, fine progress is being made. Although engineering control measures must often be employed to assist in establishing the desired vegetations, it seems logical to look to the plant world itself for the final means of natural control of excessive erosion. Before man made large-scale agricultural use of the land, Nature controlled erosion successfully and it is likely that she can do it again if given an opportunity.

The oldest civilizations that left historical evidence of their existence lived mainly in the fertile valleys of the large rivers, and their history records the beneficial effects of annual flooding of the farm lands. Layers of fertile river silt were spread over the land, the water soaked into the soil to considerable depths, and crops thrived following each flood. Beneficent Nature smiled upon her children. But these children needed wood for their fires, their homes and their Temples. They cleared the land along the rivers father and farther up into the uplands, and slowly destroyed the regulatory action of the forests in the upper watersheds. Can this be the reason for the present-day necessity of digging out the old cities from a deposit of river silt, sometimes 100 feet or more in thickness? At least it is a reasonable supposition to make. Archaeological as well as Biblical evidence indicates that our early civilizations were frequently visited by severe floods which actually destroyed them. And yet, when controlled, such floods brought beneficial results.

Utilization of water and sediment from floods has been made in recent years by some of our own citizens. One of the most interesting examples is that of the Bennett Irrigation and Silting Basin at Wilson Creek, Washington.* A watershed of approximately 475 square miles drains through Nile Creek into Wilson Creek in Central Washington. About 60 per cent of the watershed is covered with Ritzville and Wheeler soils and the remainder is largely scabland. The soils are cropped to wheat in an alternate wheat-fallow system. An earth dam has been constructed across the valley and a cement structure installed for permanent flood gates and spillway. The flooded area back of the dam is about 345 acres. Since the first flood in 1918, about 1.8 feet of sediment has been collected on

*See report—S. C. S.—Publication SS27. 1938. By Hough & Flaxman.

the cropland in 19 years. This is a little over 2 inches per year. Some years, however, nearly 5 inches have been deposited. The reason why the older civilizations found that flooding renewed their land is shown by a study carried out at the Agricultural Experiment Station in cooperation with the Soil Conservation Service. Five samples of soil were obtained for study:

1. Ritzville soil from a typical wheatfield in the drainage area above the basin.
2. Sediment from the upper end of the basin, consisting of newly deposited, relatively coarse material.
3. Old sediment, taken a short distance above the dam from a depth of 8 to 12 inches below the surface, which represents material that has been farmed for several years and subsequently covered with newer sediment.
4. Sediment deposited in 1936 along the edge of the basin a short distance above the dam, and not tilled prior to the time of its collection.
5. Ephrata very fine sandy loam from the valley floor below the dam.

The mechanical analyses showed that there was much more clay in the sediments than there was in the soil from which they came, and the following results show the high fertility of this fine material:

Soil No.	Dry Weight 1st Crop Barley	Dry Weight 1st Crop Alfalfa
	gm.	
1	4.9	19.1
2	14.8	18.1
3	7.2	17.7
4	40.8	32.5
5	4.2	12.0

This is an excellent example of the enrichment which occurs on bottom lands as a result of an ordinary flood. Such enrichment, as long as it is the result of natural erosion, can only be beneficial to man. The danger point in the proper control is in the uplands, for which the slow naturally controlled erosion should be sought. Once controlled, one may regard erosion as beneficial, both through exposure of fresh materials in the uplands with the consequent renewal of fertility, and through the slow deposition of rich sediments in the lowlands. Erosion is harmful only when not controlled, and in such circumstances it can threaten the very existence of Man.

With the assistance of their plant allies, the Federal Soil Conservation Service is waging a successful fight for control. We hope for continued success to them in their efforts toward maintaining our great natural asset—the soil.

Some Slants on Forestry and Soil Conservation

By RALPH S. SPACE
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In the short time available I will not attempt to tell you a complete story of the place forests took in the building up of the soil for this nation. To do so would require too much time. I will, therefore, pass over this point by merely stating that when the first white men came to this continent it was almost 50% forests and the soil was deep and fertile.

The early settlers were quick to recognize the agricultural possibilities of this fertile land, but before they could cultivate crops it was necessary to remove the trees. Trees, therefore, were looked upon by the settlers as a weed and a pest that retarded progress and must be removed by any and every means available. The slaughter of forest that marked man's advance across this continent has had no equal in history. There is no questioning the need to clear the lands most suited for agriculture but the hunger for timber and more farm land did not stop there but went on and on until a tremendous acreage unfit for agriculture had been stripped of its forests. Even today, with a national surplus of farm produce, much submarginal land is being cleared for agriculture.

Finally, far-sighted men of this nation saw that the destruction of our forests was progressing at such a pace that our timber resources would be depleted to such an extent that the nation would suffer if measures were not taken to conserve at least a portion of the nation's timber. Among these men were foresters who had long recognized the need for conservation of natural resources. Thus the forester was one of the first to champion the cause of conservation in this country. One might expect that he would have been interested in timber conservation alone but such has not been the case. The Act of 1897, which defined the purposes of the National Forests, states that they shall improve and protect the forests or secure favorable conditions of water flow. Thus it becomes apparent that over 40 years ago the forester was interested in maintaining conditions favorable to water flow and the Congress of the United States recognized that there was a relationship between forestry and control of waters that was of national importance. In subsequent Acts Congress has reaffirmed their action.

The fact that these Acts specifically mention favorable conditions of water flow is significant to any one interested in soil conservation since the major cause of soil erosion in the Inland Empire is water out of control. The forests now generally occupy the higher mountainous portions of the country, where rainfall is the greatest and the ground steep, which makes ideal conditions for rapid runoff and soil erosion. It is the job of the forester to so manage the forests that there will be a minimum of erosion within the forests themselves and to control the streams, leaving them so that there will be as favorable flow as possible. The term favorable flow would in this case mean a maximum amount of water distributed over a long period of time, thus making water available for irrigation, power, and other purposes without floods or destruction to land or other property.

Foresters soon learned that anything which removed the forest cover might result in uncontrolled water, floods and soil erosion unless some other cover, crop, or soil retainer replaced it in a short time. By forest cover I do not mean just trees but shrubs, herbs, litter and duff. The land-hungry farmer did not realize the necessity of protecting

the soil when the forest cover was ermoved. Had he realized this he would not have attempted to farm the steeper slopes. The result of this clearing of steep areas and lack of safeguards against erosion has been gullied and eroded farms, poverty and want. The nation now finds it necessary to replant many of these farms to trees and thereby stop the depletion and wastage of soil, and through the generations to come try and rebuild that which has been lost.

Here is an economic, social, educational and forestry problem all in one. It is an economic and social problem to devise ways and means to stop the clearing of submarginal land and to retire that which is now in cultivation to some other use. Zoning and soil classification have been suggested as solutions. It is an educational problem to teach the people of this country the need of such action, also to teach farmers that there is land that can be tilled but is not suitable for agriculture. It is a forestry problem to restore the areas best adapted to timber production to a productive state. In all these questions the forester should take an active part, working for and cooperating with the County Agents, Agricultural Economists, Soil Conservationists and others directly concerned.

Next to man, the most destructive agency to forest cover has been fire and much of it can be attributed to man's activities and carelessness. Fires have burned over large areas in the past and continue to do so each year. But it is not because of the large acreage burned alone that fires are so destructive. There is no other agency that so completely destroys the forest cover. Silviculturally fire may be beneficial since it may eliminate inferior species but so far as soil is concerned it not only kills trees but removes the herbs, shrubs, debris and duff that are so important in checking rainfall and holding the moisture until the soil can absorb it. In many instances, even the vegetable matter in the soil is burned, leaving the bare loose mineral soil in a condition easily removed by rushing waters that have no obstruction. The prevention of fires is of utmost importance to the control of soil erosion within the forests and the areas they affect below. Anyone planting trees to control soil erosion should give protection against fire due consideration.

There are other agencies that open the forests to soil erosion besides fire. In the harvesting of timber crops many of the trees are removed but since the duff and forest litter remain there should be little opportunity for erosion to start. But removing logs is heavy work and the logger desires to remove them with the least amount of effort and cost. He therefore follows the line of the least resistance and skids the logs down hill into the gulches and then down them to the creek bottoms. His skid roads thereby conform to the same branching course of the streams. The tractors, or horses if they are still used, and the heavy logs plow the forest duff and debris aside, leaving a path the water can follow unchecked. The result, in many instances, is that the water rushes down these skid-trails, tearing loose much of the mineral soil, forming a larger and larger stream until it empties into a larger creek below, often to continue its destruction there until its force is dissipated and the flow confined in the larger stream channel. Skidding of logs is as old as logging but in later years the methods have changed from horses to tractors. Thetractor has increased the size of the load many times and increased the ditch-digging effect of skidding. Of course, not all areas logged are subject to erosion, but this is one of the possibilities the forester must consider.

Many forest areas are used to graze domestic stock and where the ground

is not too steep a limited amount of grazing can be allowed without danger of soil erosion. But such is the farm economy of many stock-raising communities that in order to maintain their existence the ranchers must use all available range to its full capacity. They not only graze all range lands on or near their ranches but often ship and drive their stock many miles to reach summer range. The results are that many forest ranges are used for grazing purposes that due to their steepness and light soil can be grazed only very lightly or not at all without damage. The removal of the sparse forage from these areas and the trampling of feet destroy the agencies that ordinarily trap precipitation until the soil can absorb it. This unabsorbed water trickles down the steep hillside, tearing away small particles of soil and joining with other small streams, soon forming a larger stream and tearing a gully.

The dire need for range makes it necessary that some stock be driven long distances over rough country. Since this stock must travel through ranges belonging or allotted to other stockmen, their routes are confined to narrow driveways. Continued use of these driveways year after year by large numbers of stock breaks the sod and forms a trail or rut down which waters course, eroding away the soil and forming an ever-deepening and widening channel. The social and economic problems involved in managing forest ranges are almost, if not more, complicated than the submarginal land problem. The solution of these problems is the task of the forester.

Livestock is not the only agency that destroys the forest cover by trampling. Man himself is sometimes guilty of this offense. Public camp grounds constructed at convenient places or points of interest, where people collect in large numbers, are often damaged. Cars driven to these areas will break the forest cover if not confined to a definite route by barriers. But even though car damage is held to a minimum we find that the pounding of thousands of human feet pack the soil and kill the small undergrowth and sometimes even large trees near the most favored spots. When this material dies the use changes to another location until this is also stripped of vegetation. Thus a camp ground is progressively opened to the destructive forces of rain and flood making it necessary to close the camp long enough for it to recover.

Forests have played an important part in building up the soil of this country and there does not seem to be any other crop that is so effective in holding soil on steep mountain slopes, and trees are being planted by the millions to prevent soil erosion by wind and water. But the forester must be constantly on the watch for agencies that will undo what the trees have accomplished.

Almost every use of the forest brings problems to the forester, and use of the forests is constantly increasing. New uses are springing up and changing methods require new solutions so that the forester must be ever on the watch for destructive forest and soil agencies, and constantly striving to prevent them.

Pneumonia Problems in Washington

By R. H. FLETCHER, M. D.
Acting State Director of Health, Seattle, Wash.

Pneumonia is an acute inflammation of the parenchyma of the lung and may be either lobar, bronchial, interstitial or combined in form. The traditional distinction has been between lobar pneumonia and broncho pneumonia. However, the etiologic diagnosis is much more important, since the intelligent treatment of a patient depends on it.

Most of the lobar variety and about one-half of the bronchial variety are caused by pneumococcic infection; most of the remainder results from infection with one or more of the following: streptococcus hemolyticus, Friedlander bacillus, staphylococcus aureus, influenza bacillus, or possibly, a filterable virus. Occasionally cases may be caused by other non-bacterial agents.

In 1934 there were 1,100 cases of pneumonia reported in this State; 1935—1,318; 1936—1,304; 1937—1,261 and 1938—1,086, or a yearly average of five years of 1,214 cases reported. These reports cover all forms of pneumonia. During the same five year period there were 5,353 deaths reported or a yearly average of five years of 1,070 deaths giving a mortality rate of 65.5. It is apparent at once when the deaths so nearly approximate the total cases reported that reporting of cases is far from complete. It is, therefore, not possible to gain an accurate picture of the incidence of pneumonia in this State until reporting of cases of the infection is more nearly completed. However, assuming the mortality picture is more nearly accurate, we may conservatively estimate that approximately 4,280 cases occur annually. This estimate is based on the conservative mortality ratio of one death to four cases which has been found rather close in a number of studies.

If the average experience of the past with respect to the incidence of the various types of pneumococci holds true then a high percentage of the total pneumonias will be due to pneumococci of Types I, II, V, VII and VIII. Since specific therapy is now recognized for these in addition to others of the pneumococci types and further since the physician looks to the laboratory for aid in the determination of type or bacteriological diagnosis, I shall limit my remarks today to the problems due to pneumococci pneumonias.

There are thirty-three types of pneumococci. Certain of these types occur more frequently than others in human disease. About one-half of all the cases of pneumococci lobar pneumonia are caused by Types I, II, V, VII and VIII. The Type I pneumococcus alone is responsible for about one-quarter of all cases of lobar pneumonia. In infants and children the common types have been reported as XIV, VI, XIX and I in the order of frequency named.

Types I and II pneumococci are rare, and Types V, VII and VIII relatively uncommon in the throats of normal individuals, or in individuals who are suffering from ordinary upper respiratory infections. These types are not infrequently present in the throats of many at the time of type specific epidemics or in direct contacts of pneumonia cases of these types. Types III, VI, XVIII and many of the types above XX are commonly found in normal throats.

It is often difficult to determine in cases of these latter types associated with symptoms of pneumonia whether the pneumococcus found is the etiologic agent of the disease or whether it represents a type harbored in the upper re-

spiratory tract of these patients. The differentiation rests largely on a careful study of good sputum specimens by a competent bacteriologist and on the results of blood culture.

Typically the onset of pneumonia is characterized by chill, pain in the chest, cough with expectoration of rusty or bloody sputum and elevation of temperature. Actually, the presenting symptoms may be any one or combination of these, and the occurrence of such should arouse the suspicion of pneumonia. A careful bacteriologic examination of the sputum should be carried out at once, since early therapy offers the best chance of recovery for the patient.

It is considered advisable to obtain material for typing before chemotherapy is started, since it is said that these drugs occasionally alter the pneumococcus so that typing may be very difficult if not impossible.

A blood culture taken prior to the onset of serum or chemotherapy may serve as a check on the sputum typing. It is also valuable in prognosis and as a guide to therapy in any given case.

So far in this presentation I have referred to the laboratory responsibility in the pneumonia problem only from the standpoint of bacteriological diagnosis. This aid from the laboratory is equally important whether the case is to be treated with sulfapyridine or type specific anti-pneumococcic serums.

I feel it desirable to emphasize at this point that laboratory technicians assume a position of extraordinary importance in the conduct of pneumonia programs. Accuracy in bacteriological diagnosis, pneumucoccus typing and blood culture work is absolutely essential for the successful control of pneumonia mortality by specific serum therapy. It is, therefore, necessary for any laboratory serving the medical profession to be properly equipped and competent to give such assistance to the physician in the handling of pneumonia patients.

Recently the advance of chemotherapy in pneumonia through the use of the drug sulfapyridine has materially assisted in the reduction of pneumonia mortality. However, this form of therapy introduces additional problems for which the physician again looks to the laboratory for assistance. There can be little doubt but that the introduction of sulfapyridine in the therapy of pneumonia represents a great advance in the treatment of this disease. There are certain obvious advantages in the use of the drug in cases where serum therapy is used with hesitation, such as in patients with "known allergy" to horse or rabbit, with congestive cardiac failure or with cardiac arrhythmia and in the extremes of life. On the other hand, patients with hepatic or renal disease, granulocytopenia, severe vomiting or in post-operatives where vomiting should be avoided, ought to be treated with serum rather than sulfapyridine.

Sulfapyridine therapy has certain unfavorable aspects. The absorption, excretion and degree of acetylation of the drug are very irregular in different patients and these factors cannot be predicted. There is reason to believe that the optimum dose is that which results in a concentration in the blood of 4 mg or more per 100 cc of the non-acetylated form of sulfapyridine.

Acetyl-sulfapyridine. the combined form of the drug, is not therapeutically effective and is more toxic than the free form of the drug, but its formation to some degree always occurs. Hemolytic anemias, both the severe acute type or the milder delayed type, may occur following use of the drug. Agranulocytosis has been observed, usually after ten days or more of treatment, however, it may occur early.

One of the most important complications of sulfapyridine therapy concerns the renal function. Hematuria has been

noted with considerable frequency and has often been associated with symptoms suggesting renal colic. Nitrogen retention and edema have been observed. The acetylated form is less soluble than the non-acetylated form, resulting in the percipitation of crystals which have been found in the urinary tract of fatal human cases. Frequently crystals may be seen in voided urine.

I have covered the treatment and complications resulting from sulfapyridine very sketchily to serve as a background for the laboratory portion of responsibilities in chemotherapy of pneumonia.

First, a determination of blood level of the drug. The Marshall test or a modification of it is perhaps most widely used. At least one blood determination is desirable (12-18 hours after institution of therapy) since individual variations in absorption, acetylation and excretion are common and may require a dosage adjustment depending on free level in the blood.

The occurrence of blood dyscrasia makes it desirable to have a frequent examination of red cell count, Hemoglobin and differential. The knowledge of excretion of the drug in the urine will assist the physician in evaluating therapy adjustment.

Laboratories equipped and staffed to assume responsibility for their part in the control of pneumonia mortality can be of inestimable assistance to the physicians and are indispensable to an adequate control of the disease.

In summary, I have pointed out the following: First, that a definite pneumonia problem does exist in this State; and, secondly, that if existing laboratory facilities were made available for typing, blood level determinations, blood picture analysis and urinary determinations as a means of evaluating chemo-therapy, the physicians of the State would be materially assisted in the control of this disease. Although this subject has been covered very briefly, and only a few of the facts relative to the therapy and courses of the disease have been brought to your attention, many more will be found in the literature.

I trust this briet outline will serve to arouse your interest for further reading and study of pneumonia particularly as to the part you may share in the efforts made to reduce the mortality from this disease.

Mycetozoa: Fungus-Animals

By WALTER FLOWERS

These are slimy, filmy, mould-like masses, of visible, and often considerable, size, which live in damp places, and creep over rotting wood, decaying leaves, humus soil, etc. Later they become converted into spores and spore cases which are often elaborate and beautiful. Over four hundred species are known and scattered all over the world. And are to be found in the arctic zone as well as in the tropical countries. Some species are to be found in nearly every country where man is to be found.

The ordinary plant body, called the PLASMODIUM, is a mass of protoplasm, much like the white of egg in consistency, lacking walls but containing many nuclei. In some species it is compact in form and only a few millimeters in diameter; in others it is a loose open network, as pictured in the interesting slides you will soon see. Sometimes they form irregular films or sheets several inches across. The lack of walls and the relatively great size of these plasmodium render them very favorable subjects for extensive investigations upon the characteristics of the plasmodium. In color they are typically

white or yellowish, but are also pink, violet, and other tints, though they never display the green substance of chlorophyll. Ordinarily the protoplasm lives upon some damp organic substratum upon which it feeds saprophytically, often ingesting, like an animal, solid pieces of substance from which it later digests the nutrient materials. Commonly it exhibits active streaming and other movements, whereby it creeps over the substratum like an animal, e. g. the Amoeba. It becomes quiescent in times of dryness, and renews its activity during humid intervals. Ordinarily it keeps away from light, and hence it is to be found in crevices, or under damp objects. But when about to produce spores, the plasmodium moves out from the shelter, rises to the summit of the object beneath which it formerly lay, and there these proceed to convert its entire substance into sporangia, one or a cluster, containing asexual spores. The sporangia, easily visible to the naked eye, have usually a supporting stalk, a firm wall, and an interior lacy-delicate framework, called the CAPILLITIUM. This capillitium by its swelling hygroscopic movements, pushes out the spores, which are thus removed by the wind. It differs greatly in form in the different species, and often, like the sporangium wall, is brilliantly colored. Thus the sporangia exhibits a diveristy and beauty of which the plasmodium contains little suggestion. In the formation of the spores occur certain nuclear fusions which suggest fertilization, the lowest traces thereof known among plants.

The spores possess thick cellulose walls, and are true resting spores. After dissemination, they germinate in water and form unicellular free-moving swarm spores, which recall the Flagellata. They swim about for a time, living saprophytally; then they come to rest and form amoeba-like bodies, which multiply by fission. Ultimately the creep in groups, and these into larger groups, until they form a new plasmodium. Morphologically, therefore, the plasmodium is a kind of colony, in which the individuality of the original members has become completely merged. The plasmodia reproduces also in other minor ways, notably from separate hard fragments, or sclerotia, which, on access of water, produces new plasmodia. The most striking of all the Myxomycetes, in regard at least to its plasmodium, is (Aethalium septicum). Its favorable home is old tan bark (whence its name "flowers of tan") and its yellowish slimy plasmodium often reaches a foot in diameter, though the spore formation is inconspicuous. Mostly the group has no particular ecomic to man's interests, but one parasitic form produces the damaging "club root" of the cabbage.

The Myxomycetes exhibit relations to animals so close that some biologists have placed them in that group, and this position is expressed in one of their names (Mycetozoa: the Fungus-animals"). The free locomotion of their amoeboid plasmodium, and the free ingestion of solid food, are animal characteristics, but their elaborate sporangia and cellulose-walled spores are wholly plant-like.

Ecologically the Myxomycetes are free-moving saprophytes. Phylogenetically, they show closest affinities with the Flagallata, of which they perhaps represent a highly specialized and peculiar colonial development; and thus we tentatively rank them. It is not impossible, however, that the colonial habits is primitive, the subdivision into unicellular members being subsequent.

Rural Zoning Applied to Washington

By EDWIN F. LANDERHOLM
Division of State and Local Planning Bureau of Agricultural Economics
Pullman, Washington

Four years ago a farmer brought his wife and three children from the drouth area of the Middle West to a logged-off forest area in a certain county in the State of Washington, hoping to establish a prosperous farm and a good home. No one who new the poor quality of land in this locality would have thought of settling there with such ambitions. But, this man did not know! The luxuriant forest growth and abundant water supply of April, the month in which he arrived, and the optimistic statements of the company that sold him the land misled him.

Soon after this farmer had put together a combination log and rough lumber shack as a temporary home, his disillusionment began. The arduous labor of clearing land and planting crops in unproductive soil yielded him little but an aching back and frustrated hopes. Stranded on the so-called "farm" in which his hopes and life-time savings had been invested, he turned to cutting pulp and cordwood and to whatever other source of income he could find.

His home was ten miles from the nearest school, but even worse, a distance of two miles (four miles round-trip each morning and evening) was added to a school-bus route already too long. As a result, school transportation costs were increased; road maintenance costs were increased and the bus trip from home to school and return, was one step nearer to extending from dawn until dark.

This story is synthesized from hundreds of similar incidents that have occurred during recent years in the State of Washington.

In 1935 the Washington State Legislature passed an enabling act which makes it possible for municipalities to zone. This law was introduced as House Bill 108, and is Chapter 44 of the 1935 Session Laws of the State of Washington. The part of this law pertaining directly to zoning is found in Section 5 and reads in part as follows:

"For this purpose (physical development of city or county) such (city) council or board (of county commissioners), in such measure as is deemed reasonably necessary or requisite in the interest of health, safety, morals and the general welfare, upon recommendation by its (planning) commission by general ordinances of the city or general resolutions of the board, may regulate and restrict the location and the use of buildings, structures and land for residences, trade, industrial and other purposes; . . . the density of population; . . . and the subdivision and development of land."

After the enabling act is passed, the following steps seem to be advisable in zoning a county.[1]

1. The board of county commissioners appoint a county planning commission. The planning commission in cooperation with other agencies assembles data on physical characteristics of the land, population pattern, costs of public facilities, relief load, status of tax delinquency and other pertinent matters about the marginal and submarginal agricultural areas and the range and forest areas of the county.

2. The planning commission then prepares and sponsors a zoning ordi-

[1] Much of the subsequent material is paraphrased to fit conditions in the State of Washington or quoted from "Rural Zoning and Your County," Bureau of Agricultural Economics, United States Department of Agriculture.

nance and a map outlining the districts in which certain uses are prohibited; and:

"this commission conducts preliminary meetings in the rural communities to discuss the pros and cons of zoning in general; after which—

"county-wide hearings are held where those who object to the specific provisions of the proposed ordinance and the tentative boundaries laid out in the map may state their case.

"Then if the ordinance—perhaps modified by this time—receives the approval of the county board (of commissioners), the county enacts the ordinance, publishes the text and the accompanying map, proceeds to its enforcement, which implies among other things—

"the public recording of 'nonconforming uses' of land in restricted districts—that is, established uses that are not affected by the ordinance until they are discontinued.

"To cooperate with States and counties in this work, the Bureau of Agricultural Economics is extending the help of its State offices.

"Zoning, then, is a democratic process. The decision to zone is entirely up to the county itself; and the formation of the restricted-use districts is in its hands also. Before an ordinance is enacted, every citizen has a chance to express his opinion for or against it either in whole or in part.

"Zoning, then, is also a reasonable process. Established property rights are protected by allowing "nonconforming uses" to continue until they are voluntarily or equitably ended."

In the State of Wisconsin, where rural zoning has been most widely adopted and practiced,

"Hundreds of families have been prevented from settling in isolated sections and bringing on such misfortunes as usually are associated with scattered settlement. Substantial savings in public costs have thus been effected. As already established families or squatters gradually leave or have their holdings bought by county or Federal Government, existing roads and schools can be closed, resulting in further savings to local taxpayers and relief of settlers."

"(Rural) Zoning has a further advantage: linked with a program of submarginal land purchase, such as the land utilization program of the Soil Conservation Service, it can effectively change a wasteful and unproductive pattern of land use into one that will bring material benefit to the county. On the one hand, the purchase program can concentrate on buying out 'nonconforming users', such as farmers living in districts zoned for forestry. This will greatly hasten the elimination of expensive services, the closing up of school districts and roads, the ending of fire hazards due to scattered settlement, and the prevention of further destruction of the land. And zoning, on its side, in many instances, will make extensive purchase of land submarginal for agriculture unnecessary, by preventing the cultivation or settlement of areas unsuited to such use."

King County has led in zoning in the State of Washington. This, however, has been principally urban and suburban zoning.

In the immediate future, zoning of nonagricultural areas to prevent misguided settlement such as described in the opening paragraphs of this paper, can be pushed forward, because we already have available in this State a wealth of physical and economic data, which can be supplemented by land use classifications and maps prepared by farmers and others in all the communities in three-fourths of the counties in the State. This work is progressing rapidly and should be available for the entire State by 1941.

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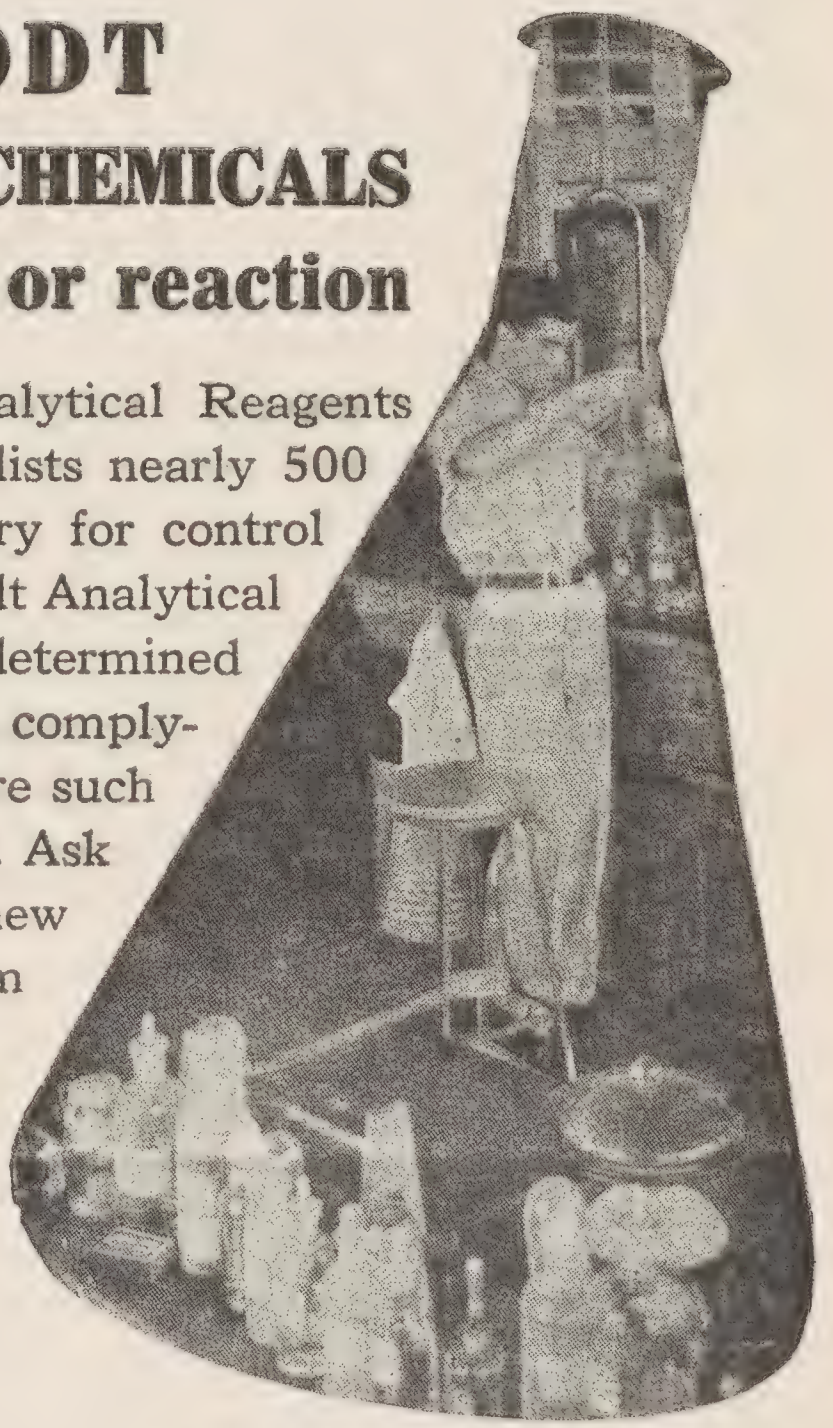

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The Species Problem in Calochortus

By MARION OWNBEY
Instructor in Botany and Curator of the Herbarium
State College of Washington

From the standpoints of morphology, cytology and geographical distribution, the liliaceous genus **Calochortus** is an admirable group in which to investigate the nature of the relationship between species and species groups.

This genus is, first of all, limited in its distribution to Western North America, from British Columbia to the Dakotas, southward to Mexico and Guatamala. Many of the species are also greatly restricted in distribution, thus affording critical evidence as to their probable phylogenetic relationships.

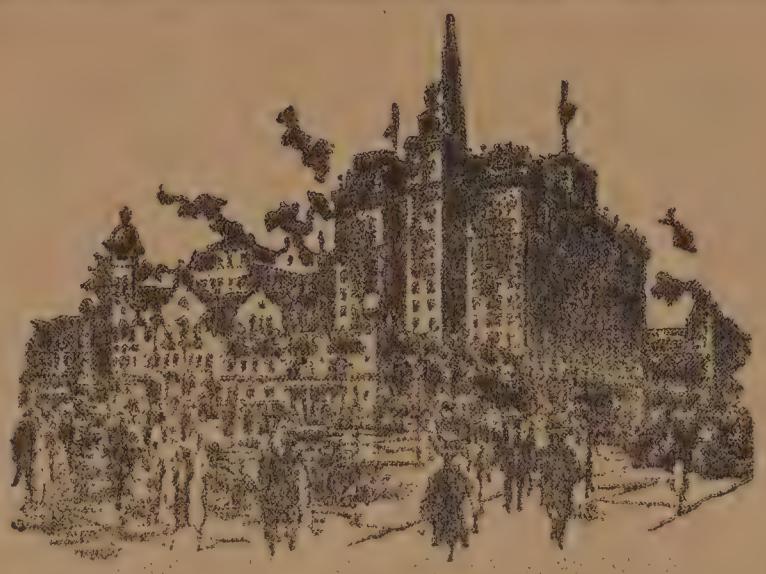
Morphologically, there is great variation within the genus, but it is easily divided into three sections and twelve subsections, which from all viewpoints seem to be natural groups.

The first major group, the Section **Eucalochortus** is characterized by ovate, 3-winged fruits, and membranaceous bulb-coats. This section is northern in distribution, and its chromosome base number is ten.

The second major group, the Section **Mariposa,** is distinguished by linear, 3-angled capsules, and membranaceous bulb-coats. This group, although widely distributed, centers in Southern California. The chromosome base number varies according to the subsection. In the **Venusti,** it is seven, rarely six. In the **Macrocarpi,** it is seven. In the **Muttalliani** it is eight, and in the **Gunnisoni,** nine.

The third major group, the Section **Cyclobothra** is southern in distribution. Its species are recognized by linear, 3-angled fruits and thick, fibrous-reticulate bulb-coats. For the most part, it is unknown cytologically, but the species of one subsection, the **Weediani,** have a chromosome base number of nine.

From the evidence presented, it is concluded that the present-day species and species groups of **Calochortus** are the result of the action of the laws of change working on related populations, separated by barriers, either external, such as geographical and ecological, or internal, such as chromosome changes, which would allow the two or more groups so separated to develop in divergent directions.



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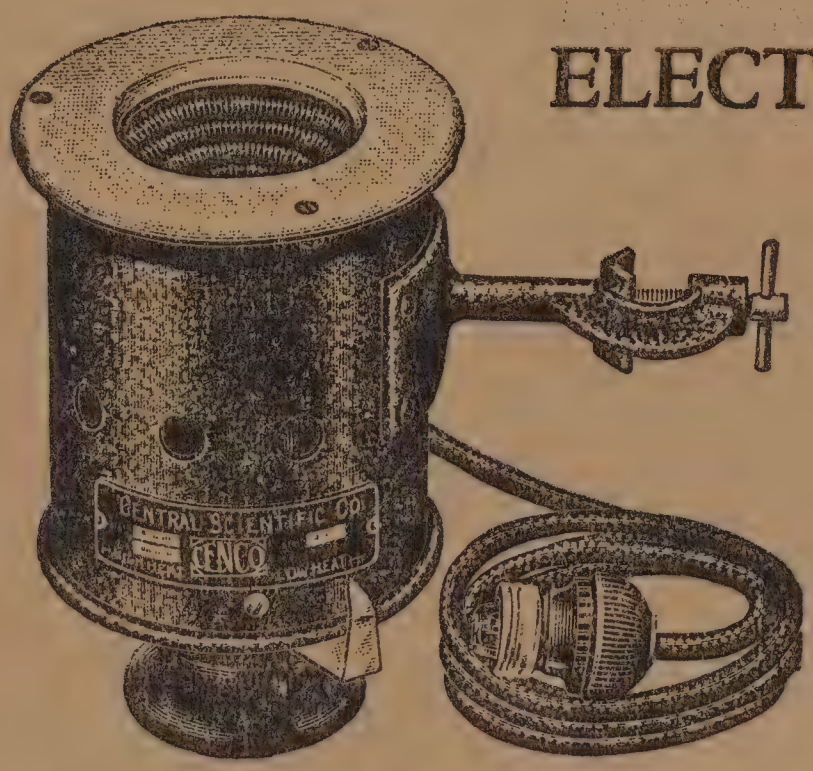

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A. A. A. S. Meeting, Seattle, June 17-22, 1940

The summer meeting of the American Association for the Advancement of Science is scheduled to meet June 17-22, 1940, in Seattle under the auspices of the University of Washington. Many scientific societies affiliated with the Pacific Division of the A. A. A. S. will hold program meetings. While the Northwest Scientific Association will not hold a separate meeting, many members of the organization will present the results of their research on various programs and all persons belonging to the N. S. A. are cordially invited to attend these meetings of interest to them. Several field trips will be offered and special attention will be paid during the meeting to problems of the Pacific Northwest, including Alaska.

Economic Aspects of Managing Western White Pine Forests[1]

By KENNETH P. DAVIS
Division of Forest Management, Forest Service, Washington, D. C.

All of you, I am sure, have wondered at one time or another what it costs or will cost to grow western white pine forests. After witnessing the flood of public money into these forests for fire protection, blister rust and insect control, stand improvement, and the like, especially during the last few years, one certainly does have reason to ask: Is it worthwhile? And, also, how far can or should the Federal Government, or any other public organization, go in trying to grow white pine for the future. For a third of a century, the harvesting of extensive virgin areas, the ready-made crop, has been the dominant consideration. Now, with the end of this harvest in sight, we must look forward to growing another crop. Most of these heavy forest investments by the public involve definite commitments to long-time timber growing, which is a quite different thing from timber harvesting. Blister rust control and disposal of defective and unmerchantable species on cutover areas to permit white pine to reproduce and grow satisfactorily are outstanding examples of timber-growing investments being made that can be realized upon only through a long-time program of timber growing.

There has been a general revival of interest in the economics of forest management in the last 3 or 4 years. Nearly 7 years of the New Deal have stimulated more economic thinking, good and bad, than any other similar period for a long, long time. The flood of money into forestry as a relief measure during the golden days of 1933-35 fed the economic senses but somewhat numbed them too. In later years, however, gradually contracting expenditures have stimulated a real interest in forest economics. The forestry structure has grown tremendously; now it is necessary to excise the weak spots and shape the rest for enduring strength. A significant trend in the last few years has been a tendency for silviculture, products, economics, and other divisions of forestry, to join forces in a common attack on forest management itself, the keystone of forestry. Cooperation and coordination are two of the most hard-worked words in conservation literature today.

The western white pine region, with its high costs and high values, very productive sites intermingled with poor sites, and highly differential values of its forest species, offers an especially fertile field for investigating the economics of forest management

My purpose here is to follow out to their logical and long-time conclusion some economic-silvicultural problems of growing western white pine forests from a public point of view. It will also be a financial point of view. You might call it the financial aspects of public forestry—a much neglected subject. First, for orientation, I'll try to sum up what seem to me some basic tenets affecting public forest management policy in this region. Then, I'll set up for your consideration two alternate systems of management with all costs counted in that are adjusted to these tenets and extend from seedling to sawlog. Many objections can be raised against any such long range "guesstimating," but the process is instructive just the same as it forces one to meet and make some disposition of the many knotty problems encountered.

Are there any basic tenets of forest

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[1]Paper given before the Forestry Section of the Northwest Scientific Association, December 28, 1939.

management in this region upon which we can agree? I suggest the following:

1. The Government is in the forest-growing business for keeps. The question is not whether the Government should manage western white pine forests or not, but how intensively and for what.

2. It seems almost inevitable that a large proportion of present privately owned timberlands, including some of the most productive, will revert to public ownership. As a consequence, the Government, federal, state, and county, is going to have an increasingly large forest land management problem on its hands; its responsibilities in timber management are just beginning. And it is obvious that the mere fact of public ownership does not solve all problems thenceforth.

3. Protection from fire, a most fundamental need, must be continued on both public and privately owned lands more or less regardless of intensity of use for timber production. The public has a wide and varied interest in maintaining a forest cover. The present trend is more and more to consider forest protection as a public function and it seems probable that this trend will continue.

4. The justification of long-time protective investments in white pine, such as blister rust control and stand improvement, depends on the future commercial value of the species. Continuance of western white pine is not necessary to the continuance of an adequate forest cover. With other species present capable of taking its place, there is no inescapable protection obligation as with fire.

5. There will be no wood famine in the United States though a shortage of quality sawlogs of choice species will probably develop. In this region, it seems most likely that in the future as at present the "pay crop" will be quality sawlogs of white pine. It is difficult for this region to compete with others, as the South, in cellulose production.

6. Aside from its protection difficulties, western white pine is an inherently desirable species in the region. Easy to reproduce, fast growing, relatively hardy, of fine form and quality, long-lived and reasonably free from defect, a high proportion of white pine in the stand would be desirable whether it had a higher unit value than other species or not. High timber volumes in the region are usually associated with a high proportion of white pine. It is high protection costs and low values for associated species that makes white pine hard to handle.

7. Finally, economics are going to play an increasingly important part in our forestry affairs. We don't give them half enough hard-headed consideration now. There are two kinds of forest management. One is physical management—keeping the forests green for their own sake. The other is a broad sort of management including all the physical orpblems but with the ever so much more complex needs and interests of human beings superimposed on top. This is a much more sensitive and finely adjusted kind of forestry. It considers forestry in relation to other things and strives to establish and maintain a harmonious balance. This is an infinitely more complex forestry—the kind we face today.

To summarize: The Government is in the forestry business for keeps. It faces an increasingly larger management problem as forest lands revert from private ownership. The future of white pine is a big question mark but the best guess is that white pine sawlogs will continue to be the main money crop. And, finally, the economic aspects of public forestry are going to demand more and more thorough consideration.

With this much for background, where are we headed? At present, the

Forest Service is, as you all know, very frankly committed to growing western white pine. On national forest cuttings, a major objective is to keep the land producing white pine, the species favored above all others. The leaving of seed trees, disposing of defective and unmerchantable timber, and blister rust control, are investments in timber **growing,** not harvesting or just keeping the forests green. Let's see where we come out with a long-time program of timber growing based on present conditions and keeping in mind the general background just sketched.

To do so, I have set up a limiting case on the favorable side by assuming a fully regulated forest, operating on an even-aged plan of management. That is, a series of even-aged stands with all age classes from seedling to mature crop trees equally represented by area. Each year an annual cut can be made removing mature trees whose volume just equals the net growth of the forest as a whole. Uniformly each year, therefore, revenues accrue and expenses must be met. Making the assumption of a regulated forest serves two very useful purposes. First, it brings out at once the long-range consequences of present policies. Second, financial calculations are greatly simplified besides (in my opinion) making them much more realistic.

Specific management assumptions made in this case are as follows:

1. The objective is to grow white pine sawlogs as the major crop. Forest composition will be held at approximately 70 per cent white pine and 30 per cent other species, by a cleaning operation performed when reproduction is between 10 and 20 years old. This seems practicable as extensive virgin areas have supported this high a proportion of white pine. I would not recommend attempting to grow pure stands —70 per cent is high enough on the average.

2. Cutting practices. Two alternative plans each operating on a basic rotation of 130 years. First, a one-cut plan of the type practiced now by the U. S. Forest Service in mature stands. Everything would be cut at rotation age but necessary seed trees which it is assumed would be later salvaged. Second, a partial cutting shelterwood system following out a detailed and coordinated silvicultural plan calling for harvest cuts at stand ages of approximately 90, 110, 130, and 150 years. The first cut is made as soon as the stand contains sufficient merchantable timber to permit a profitable cutting without depleting the stand of growing stock needed for future growth. The main harvest cut is made at 130 years at which time approximately even-aged reproduction is expected to start the new rotation. The rather open shelterwood of fast-growing high-quality trees remaining to be cut at about 150 years, consequently extends into the next rotation by 20 years. A similar overlap occurs with the single cut plan but the residual volume is much less and is of importance mainly for seeding purposes.

3. Area and yield. To give a statistical basis for the analysis grounded on fact, I have based calculations on an assumed block of forest land similar to that found in the North Fork of the Coeur d'Alene River. Those of you familiar with the area, as many are, keep it pictured in your mind. Sixty per cent of the gross area is assumed productive of merchantable timber. The rest consists of poor sites and unmerchantable cover types that are intermingled, must be protected, but cannot be counted on for commercial production. The proportion merchantable to unmerchantable was obtained by analyzing several Forest Service cutting areas in the North Fork in relation to a forest type map. Areas potentially merchantable but currently supporting immature age classes were added to the

areas actually logged over. In mountainous terrain such as this there are great variations in site quality and cover type and 60 per cent of it is, I believe, all that is worth trying to grow timber on.

Yields are based on what loggable areas in this drainage actually have produced. They are not "hope" figures in any sense; rather, I believe them conservative. The yields estimated from partial cutting, the four-cut plan, were developed out of a long drawn out and tedious stand table analysis that I can't go into here. All growth rates employed were entirely reasonable, rather low in fact, and are based on and cross checked against growth and mortality data obtained by the Northern Rocky Mountain Forest and Range Experiment Station.

So much for general management assumptions. Merchantable volumes produced under these two plans of management are shown in table 1. The larger volume produced by the partial cutting plan in comparison to the single cutting plan, estimated at 48,200 board feet per acre as against 34,000 feet in this instance, is outstanding. This difference comes about mainly by harvesting a part of the natural mortality through the intermediate cuts, and by maintaining a small but consistently higher average growth rate after the age of 90 years when harvest cutting is begun. While there's naturally a lot of rather broad estimating involved, I do feel that the relative difference between the one-cut and four-cut plan is reasonable. It is based on the best information we have.

TABLE 1.—MERCHANTABLE YIELDS PER ROTATION ESTIMATED FROM ONE-CUT AND FOUR-CUT MANAGEMENT PLANS

Species	One-cut plan	Four-cut plan; volume cut at				
	Volume cut per rotation	90 years	110 years	130 years	150 years	Total per rotation
	Per acre volume in board feet (Scribner)					
Western white pine	23,800	4,700	7,200	14,400	9,700	36,000
Western larch and Douglas fir	5,100	1,100	1,800	3,000	1,700	7,600
Lowland white fir	3,100	500	1.600	700	0	2,800
Western hemlock	1,700	500	600	400	0	1,500
Engelmann spruce	300	0	0	100	200	300
Total	34,000	6,800	11,200	18,600	11,600	48,200

The next problem is to superimpose the dollar sign on this structure of physical returns. Here is where we get into even deeper water, and once again I'll have to ask you to pass over the details of calculation and consider the net results. This isn't, of course, very satisfactory as it is perfectly obvious that the validity of the results depends on how costs and returns were calculated. But their derivation goes back quite a ways in most instances and full explanation is impossible here. All cost and value figures are based on current levels; that is, no assumptions about future trends, up or down, have been made.

The net results of my cost and value calculations are shown in table 2. The items included are those believed to be a part of any long-time program of growing western white pine forests. The three largest, blister rust, taxes, and fire, deserve some explanation.

TABLE 2.—ESTIMATED ANNUAL COSTS AND RETURNS OF GROWING WESTERN WHITE PINE AND ASSOCIATED SPECIES ON A "GOING CONCERN" BASIS

Item	One-cut plan			Four-cut plan		
	Proportion of total cost	Cost or return per M. bd. ft. log scale		Proportion of total cost	Cost or return per M. bd. ft. log scale	
		Cutting white pine only	Cutting all species		Cutting white pine only	Cutting all species
	Percent	Dollars	Dollars	Percent	Dollars	Dollars
COSTS						
Protection[1]						
Fire	9.5	0.91	0.64	8.0	0.60	0.45
Blister rust	31.2	3.01	2.11	27.8	2.07	1.55
Silvicultural						
Cleanings	3.6	.34	.24	2.9	.22	.17
Disposal of unmerchantable timber	5.0	.49	.34	2.9	.22	.16
Slash disposal	7.4	.71	.50	4.5	.34	.25
Woods administration	5.9	.57	.40	9.8	.74	.55
Improvement & Overhead						
Road construction and maintenance	7.3	.70	.49	12.7	.96	.72
Taxes	21.0	2.03	1.42	22.2	1.67	1.25
General overhead	9.1	.88	.61	9.2	.69	.51
TOTAL COSTS	100.0	9.64	6.75	100.0	7.51	5.61
RETURN[2] (stumpage value)	——	8.70	6.78	——	7.98	6.55
PROFIT OR LOSS (costs less returns)	——	—0.94	+0.03	——	+0.47	+0.94

[1]No insect control cost was included. Yields were based on what has been produced in the past without any protection against insects. It was assumed that insect control operations would save timber values at least equal to the cost of control; hence, no net cost was included.

[2]Based on an average stumpage value for good quality white pine of $7 per M plus average road, slash disposal, and stand improvement costs which are here included under timber growing costs, and not as a part of logging expenses as is usually done in stumpage appraisals. Stumpage of mixed species valued at $1 to $3 per M depending on species and estimated quality.

The blister rust figure is a compound of the cost of initial ribes suppression, general maintenance to keep the area ribes free, and reworking of areas currently logged over. It is the writer's own estimate based on data contained in the annual reports of the blister rust organization which give what blister rust control in the western white pine region has cost so far. Most of the blister rust item arises from the heavy cost of initially establishing a ribes-free condition; subsequent maintenance will be much less expensive. That a heavy investment is being made within a relatively short period that can only be realized upon many years in the future, cannot be denied. How to prorate the cost against an annual operation is a nice problem in public finance. The view adopted here was that of an owner of a regulated forest suddenly faced with this new thing, blister rust. The method employed was the normal business procedure of figuring interest and amortization on a long-time loan to cover the initial investment. In this instance a 2½ per cent rate and a 75-year amortization period was used. Whether or not this is the most realistic approach can be argued; probably many of you will not agree with me.

Taxes are based on what a large operating timber company in the North Fork has actually paid on virgin and cut-over lands. The tax item must be faced whether lands are in private or public ownership. At present, 25 percent of national forest gross receipts are turned over to the counties. Another 10 percent is reserved for forest road and trail development. Note that the tax item shown is about 20 percent of the net stumpage value. Fire control is based on a flat protection cost of 10 cents per acre per year which is approximately half the present cost to the U. S. Forest Service when maintenance and depreciation on fire control improvements are included.

Assuming that the figures in table 2 are reasonably accurate, at least relatively, what do they show?

Of first importance is that costs and returns approximately break even. When I undertook this analysis, I had the very unscientific pre-conviction that a big deficit was inevitable. When all species are assumed to be merchantable, returns almost exactly balanced costs for the one-cut plan. On the same basis, the four-cut plan shows a small positive margin of 94 cents per thousand board feet. The marked advantage of getting a positive return, even though small, on the mixed species is also evident by comparing the profit or loss margins when cutting white pine only or all species. The mixed species help carry the heavy investment and overhead charges. This analysis exposes clearly the well-known financial weakness and vulnerability of a one-species pay crop in a mixed stand, and points to the great advantage of a diversified market even though some species carry relatively low values.

Even with the four-cut plan, however, there is very little margin for return on the capital that must be tied up in land and timber. For the Government, this isn't so serious. In fact, I'll argue that its prime obligation is to maintain its capital unimpaired and not to make a profit in a strict private business sense. The Government's profit comes through the benefit to its citizens from production of a valuable raw product. Public capital acts as a catalyst in a very real sense.

What about the private investor? This analysis does not paint a very rosy picture. It should be recognized, however, that blister rust control, the largest single cost, has been assumed by the Government. Fire control is another cost that at least in part is (and in all probability will be) publicly borne. Elimination or reduction of these items would improve the picture materially.

There are, of course, other deterrants to private investment well known to all of you, such as heavy investments already made in timber and plant that press for liquidation, possibility of severe fire losses, uncertainty as to what blister rust and insects will do in the future, and uncertainty about the future value of white pine and its associates.

Even more important from the private point of view is that a perfectly regulated forest has been assumed here —something that does not exist and something that is not on the market to acquire. As I said, this "going concern" forest was set up to bring out the long range consequences of certain management policies. If a fully regulated forest cannot make a favorable financial showing, it is obvious that an unregulated forest will not. The point to be made here is just that. Unless and until approximately regulated forest units can be blocked out and operated as such, a long-time program of timber growing in this region will make a poor financial showing. The burden of carrying excess volumes of merchantable timber or of holding immature timberlands for long periods without intermediate return, is too great. This points to the desirability of thoroughly investigating the possibilities of establishing sustained yield working circles, including both publicly and privately owned timber.

Discussion of these and other points can go on and on. The possibilities certainly cannot be exhausted in this paper. In closing, there is one thought, or rather line of thought, that I particularly want to leave with you. Regardless of whether or not this particular analysis and approach has value, there is a real place and need for much more work of this nature. The next decade or two will witness large changes in this forest region. Much of the remaining virgin timber will be gone by then. There undoubtedly will be a strong trend of lands into public ownership. As I said, the public's forest management problems in the region are just unfolding. Many readjustments must be made and the economics of the situation will demand increasing attention. The place this region will take and hold in the future will depend in large part on our clearness of vision in honestly analyzing our problems and seeking practical solutions.

Trends in the Recreational Policy of the United States Forest Service

By FAY G. CLARK

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The title to this paper is somewhat a misnomer. What is being covered is only a small phase of the recreational policy of the Forest Service, since to cover this subject in its entirety would entail a thesis out of proportion to the length of time that could be allotted at a meeting of this kind. The phase to be presented should be considered more in the nature of an example of the adjustments and trends that must of necessity occur in the administration of any public lands devoted to multiple use.

In this case, the example offered is the conflict (if the word 'conflict' can be used) between that recreational use now having priority, i. e., free use of the forests for campers, hikers, picnickers, and others of this type, and that which now has the lowest priority: the smaller group using the forests for sites for summer homes under special use permits or leases.

The forests have been used for camping, hunting and fishing since the first settlers came into this Western country. Prior to 1915 this was probably not considered or thought of by the average forest officer as a use of the forest that should be particularly provided for in his simple land use planning. Neither, during this early period, was this phase of forest recreation a particular problem. In some of the crude early plans for special use development at the more popular lakes, provision was made for camp grounds, but this was done largely as a measure of protection to the summer home permittees. It was felt that by providing camp sites the campers could be concentrated at these spots and not overrun the premises of the permittees.

While the policy as laid down in the Administrative Manuals may not have changed materially since 1922, the effectiveness by which it was carried out by the field personnel was another matter. After all the effectiveness of any policy, good or bad, depends on the manner in which it is carried out by an organization's personnel and the interpretations of the policy made by the field officers on the ground. In reality, we are dealing more with an attitude than with a policy.

The basic policy governing the administration of the National Forests was clearly laid down by the Secretary of Agriculture, James Wilson, in his letter to the Forester dated February 1st, 1905. He stated in part: "The resources of the National Forests must be 'devoted to the most productive use, for the permanent good of the whole people and not for the temporary benefit of individuals or companies"; and again: "Where conflicting interests must be reconciled the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

This is perhaps the most far reaching statement of public service policy ever written, and the Forest Service during its 35 years' existence, has done its utmost to adhere to its principle in its administration of the Nation's forests, except where it has had to be modified either because of political expediency, or because of the development of new uses. The policies of any governmental service can be modified by public opinion whether for good or bad. In a democracy, such as ours, strongly organized, well financed, self-seeking mi-

norities may hold in abeyance or even defeat and destroy policies that are for the public benefit. The history of these attempts to defeat the policies of the United States Forest Service, and in some cases to even destroy the organization itself, is well known. As a matter of self-preservation, political expediency in some cases had to be followed and policies changed or modified.

One of the most important of these political expediencies was Gifford Pinchot's promise to the anti-conservation group that the National Forests would be self-supporting in ten years or less. As a result of this promise every effort possible was made by the Service personnel to foster those activities that would produce revenue, and at the same time lessen the expense of administration. In this regard the policy affecting Recreation was the one most grievously upset. Priority was given those recreational uses that in the light of Secretary Wilson's letter above quoted should have been given the least consideration. In this instance the largest revenue producer was the Special Use Permit for summer homes. In addition to the revenue derived from these permits it was soon discovered that once the summer resident had developed his building site and had an investment to protect, he became an efficient and responsible fire warden within his immediate vicinity. He likewise became an ardent fire prevention advocate and his efforts along this line had a profound influence on the forest protection education of the general public. From the field officer's point of view this produced an ideal situation: an additional protection force that cost nothing and actually paid for the privilege! In view of this, the most choice spots in the National Forests were placed on the market and the prospective tenants for these sites were often given high pressure sales talk to get their names on the dotted line of the Application Form. To aggravate the situation still further, the use of the National Forest lands for free use recreation was not marked, being limited to the local residents of the nearby towns or cities. Such limited numbers that took advantage of the free use facilities of the National Forests were, in many cases, an actual nuisance to the destructible resources due to their carelessness with fire.

As an example of this somewhat distorted viewpoint, one Ranger beset by fishermen and transient campers along a well-known and popular river, succeeded in issuing permits for summer homes to his local urban residents covering nearly all of the best camping spots along the river. This was by no means an uncommon situation. Thus the demands of the general public for camping space and an opportunity to enjoy a short outing in the forests meet with a marked, stubborn, passive resistance on the part of the field personnel. They were regarded in the light of a menace and a general nuisance to all concerned.

Naturally, in a situation of this kind, there would develop, sooner or later, antagonism and resentment between the two classes of forest users. The summer home permittees were more or less at the mercy of the campers, hikers, and picnickers. These over-ran the premises of the summer homes, often doing direct and serious damage to the property. The campers resented having the best and most desirable spots in the forest occupied and devoted to the exclusive use of a favored few. This opposition to the summer home owner eventually reached the floor of the Senate where it was said: "That certain forest reservations were made for the sole purpose of furnishing summer homes for certain gentlemen who like that kind of life." Meanwhile the usual gossip was rife that there was going to be a general cancellation of all the

summer home permits. An echo of this even persists at the present time.

As this opposition to the permittees developed, they in turn whipped up considerable sentiment for their side among the Western Senators and Representatives. These political gentlemen, quick to take advantage of any opportunity to cripple the conservation movement, took up the cause of the 'poor summer homesteader'! ! It was the same old song with the same words that had been used for many years previous in the battle to open the National Forests without restriction to the provisions of the Homestead Law: i. e., that these men were attempting to build permanent homes in the forests where they could rear their families in God's great out of doors and even their children's children: they were developing the country, increasing the taxable wealth, etc., and that they should be assured permanency of tenure on the land through being able to acquire title to it, even if only 5 acres. The movement was endorsed by the Western Governors' Conference meeting in Denver in April, 1914. Many of the Western Congressmen made it a part of their political platforms, in running for office. In the House of Representatives, Raker of California, supported by Taylor of Colorado, introduced a Summer Homestead Bill September 21, 1914. It provided a limit of 10 acres to the area that could be acquired; three summers' of residence of two months each summer and improvements to the value of not less than $300. It also provided a payment of $1.25 per acre at the time of final proof. It was supported by the Interior Department which urged its passage.

Sufficient opposition was developed to the bill, however, that it was lost on a point of order. As a counter measure, the Forest Service was trying to secure authority for the Secretary of Agriculture to issue term permits not to exceed an area of five acres or a length of life of more than 20 years. However, the opposition for the Homestead Bill also opposed the granting of long term leases or permits. At this stage of the controversy many of the Congressmen became actively opposed to having any summer homes in the National Forest and favored excluding all permits of this character from the National Forests. As a result of this opposition, it was not until February 4, 1915, that the legislation proposed by the Forest Service could secure any recognition in either house of Congress. On this date Senator Smith of Georgia offered an amendment to the Agircultural Appropriation Bill, giving the Secretary of Agriculture authority to issue term permits for recreational purposes not exceeding 5 acres in area and for a period not exceeding 30 years. This was finally passed March 4, 1915.

The passage of the Act had little effect on the attitude of the field personnel. They still favored the exclusive Special Use Permittee and felt that the passage of the Act was in reality a justification of their Special Use policy, instead of a compromise between the proposed Summer Homestead Law on one hand, and the complete exclusion of summer home special use permits from the National Forests on the other. But since the public could not be stopped from camping, camp sites were designated and reserved on all lakes and at other points. Little was done to improve these, due perhaps from the lack of funds, but beyond a doubt due largely to the attitude of the average field officer who was still hostile or indifferent to the welfare of the campers. It was only under the guise of better forest protection that these men were won over and that camp ground development received any consideration at all. By concentrating the campers at central points it was felt that better fire protection could be afforded the

forests. All of this argument was somewhat fallacious because more fires were set by hikers and fishermen and others than by campers.

However, by 1920, considerable publicity was being given the development of public camp grounds and the use of the National Forests for recreation. Opposition again arose to this policy in the form that the National Forests were taking over the functions of the National Parks and were duplicating their activities. This never got to the point of a political issue due to the Forest Service 'soft-pedaling' the whole recreational program and stating a definite policy on this in the Administrative Mnaual that: "It is not the purpose of the Forest Service to duplicate within the National Forests the functions, methods, or activities of National, State or Municipal park services, nor to compete with such parks for public patronage or support. Recognition must, however, be given to the occurrence within the National Forest of mountains, cliffs, canyons, glaciers, streams, lakes and other landscape features; natural formations such as caves or bridges; objects of scientific, historic and archaeological interest; timber, shrubs, and flowers; game animals and fish; and areas preeminently suited as sites for camps, resorts, sanatoria, picnic grounds, and summer homes. These utilities, which singly or in combination afford the basis for outdoor recreation, contributing to the entertainment and instruction of the public or to public health, constitute recreation resources of great extent, economic value, and social importance. No plan of National Forest administration would be complete which did not conserve and make them fully available for public use. Their preservation, development and wise use for the promotion of public welfare is an important and essential feature of forest management which adequately should be coordinated with the production of timber and forage and the conservation of water resources. The areas now constituting the National Forests have been used for recreational purposes since the first settlement of the country and such use naturally will grow as the population increases and as wild land is converted to cultivation."

It will be noticed from the foregoing declaration of policy that the Forest Service had no intention of duplicating the efforts of the National Park Service, but that it had under its control a huge recreational resource, and, come what may, it was going to do its utmost to develop it along with the other resources of the forests.

Priorities in recreational use were also set forth in the manual at this time. The highest priorities were given to public camp grounds, motor camps, play or picnic grounds; next came those maintained by the various political subdivisions for use of the general public; then in order the semi-public organizations; fraternal or charitable organizations; public utilities, such as stores, boat ilveries, etc., where there was a public need for such services, and last on the list "summer homes for the exclusive use of permittees and their families."

Thus, under this policy, recreation was a resource that would pay few dividends into the Federal Treasury and Pinchot's promise of self support died a hard death. Prior to the early 1920's there was seldom an opportunity missed at the hearings on the Agricultural Appropriation bills to pointedly remind the Forest Service of this fact. The loss of taxation to the political subdivisions through the inclusion of lands in the National Forests that might have gone into private ownership and thus onto the tax rolls was and still is a perplexing problem and one that in the future might again change the entire recreational policy of the Forest Service and place it back on a hard and fast mone-

tary "pay as you go" basis.

With the complete change from horse to motor transportation during this period and the construction and improvement of roads, the use of the National Forests for camping purposes received a tremendous impetus. Ten campers grew to a hundred and in some cases to a thousand. No longer did they come from the local residents but from distant regions. They had to be taken care of. With the advent of this horde of forest users, Pinchot's ancient promises had to be shelved. No longer did the politicians remind the Forest Service of them, even when appropriations were requested or diverted for recreational development of the forests for the use of the general public.

Regardless of the policy as laid down in the Administrative Manual, the field officers still continued to give a very grudging attention and consideration to the camper, the casual visitor, and the so-called low income group of citizens. These people were, in the minds of the Rangers, a menace to the general welfare of the forest and everything contained therein. These field officers, as far as they were able, continued to give preference to the summer home permittee, largely because he was an asset and not a liability. He did not have to be constantly watched and in addition would render valuable aid when requested. Regardless of the efforts of the supervisory personnel, this situation continued until 1932.

The advent of the New Deal Administration with its extreme socialistic tendencies had a marked effect on the attitude of the field personnel. Recreational development of the National Forests was taken out of the hands of the field men and placed in the hands of specialists working under the immediate direction of the supervisory officers. These specialists have made and developed the recreational plans of the various forests where the need was apparently the greatest. The priorities for the various recreational uses that had been promulgated a decade previous were now given full force and effect. While, of course, such is probably not the case, it would seem from the plans and the development that is being undertaken by the Forest Service that the once lowly camper and casual visitor is now placed at the head of the ilst of preferred uesrs. They have apparently become a benevolent government's chosen people. Highly trained, and also highly paid, landscape engineers are designing camp grounds, the beauty of which, in many cases, would do justice to a municipal park. Battalions of CCC boys and WPA laborers are carrying out the plans. Tables, fireplaces, toilets, community houses, water, piped, often, to the tables at considerable trouble and expense, and fuel furnished free of charge on the premises are in many instances the order of the day. In many cases garbage service is furnished better than that given by a city. Only the lack of funds appropriated for the purpose apparently prevents the construction of hotels and summer cottages in the most choice spots on the National Forests for the benefit of these people. One hotel has been constructed for the benefit of the "low-income" citizens and perhaps it is justified. As the late Robert Marshall expressed it in a letter to the author, "If we can't bring the mountain to these people, we will bring the people to the mountains." How far this trend of policy will go no one can tell.

In the development of the recreational plans it has been found that many of the most choice sites within the forests have been diverted into private hands by the special use permits for summer homes, and other paying uses. Are the most valuable of these permits to be extinguished and their use diverted to the general public? This is a question uppermost in the minds of many of the

permittees having a sentimental attachment to the site as well as an investment of considerable amounts in improvements on the land. To date the Forest Service has been just and fair in the protection of these individuals in their rights to the land. No permits have been cancelled except with the consent of the permittee. A few have been revoked because of flagrant violations of the terms of the permits. Nevertheless the situation from a political standpoint seems dangerous to the welfare of the National Forests, especially so when the Recreational Act of June 1. 1938, of the Interior Department might easily be amended to apply also to the National Forests. This Act provides fro the outright purchase of the land in tracts not exceeding 5 acres.

It no doubt will be necessary eventually to extinguish many of these special uses where higher priorities for the areas are evident, or where they may develop in the future. In view of the basic policy of the Forest Service this will have to be done with the least possible loss to the users and over a sufficient length of time that the adjustments between the high and low priorities of land use will be so gradual that the good will of the recreational public will be maintained and summer home and other special use permittees will not lose faith in the stability of the tenure of the special use permit. When this is done and the carefully prepared plans for the future use of these lands are adhered to, the policy of "the greatest good of the greatest number in the long run" will then be firmly established.

ABSTRACT

Translocation of Radiophosphorus From Bean Leaves*

By O. BIDDULPH

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Bean leaves (Red Mexican) were "injected" with radiophosphorus and subsequent movement traced by assaying various tissues by means of a Geiger counter and appropriate recording circuit.

The results of various types of studies indicate that (1) radiophosphorus migrates readily from the leaves to other parts of the plant, and (2) that the ultimate distribution is the same as would be had if the radiophosphorus were placed in the nutrient solution.

The amount of radiophosphorus migrating from the leaf varies directly with the amount "injected" and also with the time allowed for migration (up to 8 hours).

The ultimate distribution of the major part of the injected radiophosphorus is to the actively growing regions, i. e. the stem tip and young leaves, and the roots.

Two conditions which decreased the amount of radiophosphorus migrating were (1) continued darkness after injection, and (2) phosphorus deficienfy in the tissues.

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*The writer wishes to acknowledge, with gratitude, the aid of the National Research Council and the American Academy of Arts and Sciences, in supplying money for equipment used, and to Drs. E. O. and E. H. Lawrence for the generous gifts of radiophosphorus.

Sweet Clover as a Conservation Crop in the Palouse[1]

By ARDEN W. JACKLIN and VERLE G. KAISER[2]

Soil Conservation Service, Moscow, Idaho

Continuation of a profitable system of agriculture in the inherently cash grain-producing Palouse area of eastern Washington and northern Idaho depends primarily upon the conservation of its soil resources.

Cropping systems used on Palouse farms consequently must provide for both conservation of the soil itself and maintenance of soil fertility. They include soil-improving forage crops grown in systematic rotation with soil-depleting grain crops. The frequency with which the soil-improving crop is used in the rotation is determined by the type of forage crop itself and the soil requirements for erosion control.

Soil-improving rotations adapted to a major part of the land in the Palouse vary from four to seven years and include biennial sweet clover as the base soil-improving crop.[3] A typical rotation that is being used widely is six years long. It consists of tall white biennial sweet clover alone, with grass, or with peas as a companion crop, the first year; sweet clover for green manure, hay, pasture or seed the second year; cash grains the third and fourth years; peas or summer fallow the fifth year; and cash grain the sixth year.

Sweet clover has been raised for many years on Palouse farms, but only during the last decade has it appeared in systematic rotations.[4] In the South Palouse Project, approximately 220 fields comprising some 24,000 acres have been seeded since 1934 to sweet clover or to sweet clover and grass in soil-improving rotations.

Records have been kept on the effect of the sweet clover crop in succeeding grain yields and on erosion control for many of these fields. This paper, however, deals only with information obtained from 44 fields seeded to sweet clover or sweet clover and grass in 1936. These 44 fields, all of which are situated on typical farms in the demonstration project, total 2,160 acres.

A complete plan of improved land use practices for soil conservation was in effect on these farms prior to 1936; hence, only soil, slope and erosion conditions under which soil-improving rotations were deemed adequate for erosion control were included in the study. This paper must be considered as a discussion of progress, because data from which it is drawn do not cover a complete rotation cycle.

Twenty-four fields studied were Palouse silt loam, fourteen Thatuna silt loam, three Koster silt loam, two Palouse silty clay loam, and one Santa silt loam. This distribution was proportionate to the extent of these soils in the South Palouse Project.

Data have been obtained by field observation and study on one grain crop and the first two years' erosion following the use of sweet clover and sweet clover and grass. Summarization of the material for this paper consisted of listing various factors which might influence erosion and grain yields. All of

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[1]Contribution from the Soil Conservation Service, U. S. Dept. of Agriculture.

[2]Area Agronomist, Idaho-2 Area, and Project Agronomist, South Fork Palouse Project, respectively, of the Soil Conservation Service, Region 9.

[3]Sloan, Sam L., Jacklin, Arden W., and Kaiser, Verle G. Soil-conserving and soil-improving crop rotations for the Palouse. Jour. Amer. Soc. of Agron. 31: 300-313. 1939.

[4]Schafer, E. G., Wheeting, L. C., and Vandecaveye, S. C., Crop Rotations. Wash. Agric. Exp. Sta. Bulletin 344. 1937.

the field data then were applied to each variable individually without regard to interplaying relationships between the variables. These relationships can be obtained only by considering each factor separately and then reviewing them all as a unit.

A Comparison of Wheat Yields Before and After Sweet Clover and Sweet Clover and Grass.

A comparison of grain yields before and after the use of sweet clover and sweet clover and grass was made on all fields which produced wheat in 1935 and 1938.

In 1935, before soil-improvement cropping, the average production of these fields was 29.9 bushels per acre. In the first crop after the soil-improving crop, they produced an average of 42.3 bushels per acre, or an increase of 41 percent. Average grain yields in the area were very similar in 1935 and 1938. Twenty of the 22 fields in this group were cropped with winter wheat in 1935 and 1938, and two with spring wheat.

Yield of the First Wheat Crop After Sweet Clover as Affected by the Inclusion of Grass With the Green Manure Crop.

A comparison was made between the yields of grain before and after plowing down the two types of green manure; i. e., sweet clover with grass and sweet clover alone. An increase of 15.2 bushels per acre, or 59.2 percent, after sweet clover and grass resulted as compared to a 12-bushel, or 38.1 percent, increase after sweet clover alone. The fields on which a mixture of grass and clover was used, though, generally were more severely eroded and in a poorer condition prior to the use of the soil-improving crop than were those on which sweet clover alone was planted. On the fields where sweet clover alone was grown, the clover had been established during the first year with peas as a companion crop.

Yield of the First Crop Following Sweet Clover and Sweet Clover and Grass as Affected by the Tonnage of Green Manure Turned Under.

The amount of green manure was divided into classes as follows: Light, under five tons per acre; medium, from five to ten tons per acre; and heavy, ten tons or more per acre. The same classification of tonnage of green manure is used throughout this paper.

Total tonnage of green manure turned under at or before the early blossom stage varied from 2.25 tons per acre to 19 tons per acre. Sweet clover pastured or cut for hay or seed yielded four to twelve tons per acre of aftermath, which was turned under in the fall.

Twenty-two fields were cropped to winter wheat and 14 to spring wheat after the soil-improving crop was plowed.

Of those seeded to winter wheat, seven were on light green manure fields and averaged 42.4 bushels per acre; six were on medium green manure fields and averaged 42.5 bushels; four were on heavy green manure fields and averaged 42.5 bushels; and five were on pastured green manure fields and averaged 39.8 bushels per acre.

These data show little correlation between the tonnage of green manure plowed under and the yield of winter wheat in the first crop following.

Yields of spring wheat in the different tonnage classes showed about the same variation as was found in the winter wheat. The heavy tonnage and the pastured classes gave a slightly lower average yield than the light and medium tonnage classes. This decrease may have been the result of moisture lost while preparing a satisfactory seed bed for spring wheat or to open, porous seed beds, both of which conditions may have been caused, in turn, by the large amount of crude organic matter that was present in the surface soil.

Greater variation in yields of the different tonnage groups may be expected later in the rotation cycle.

Yield of the First Wheat Crop After Sweet Clover and Sweet Clover and Grass as Affected by the Intensity of Tillage and Resultant Soil Pulverization.

The surface condition of the field, measured in degree of soil pulverization, was divided into three classes, namely, fine, medium, and rough. Fields were inspected prior to the run-off season.

The average yield of winter wheat on nine fields which were finely pulverized was 47.3 bushels per acre. On nine fields left in a rough condition, the average yield was 39 bushels per acre, a difference of 8.3 bushels in favor of the finely worked fields. The high yields from the finely worked fields were accompanied, however, by serious erosion and undesirable physical condition of the soil. These points will be discussed later in the paper.

The average yield of winter wheat on fields pulverized to a medium degree was very similar to those resulting from a rough condition.

No significant difference was noted in the yield of spring wheat on fields pulverized to varying degrees prior to the first run-off period.

Erosion as Affected by the Tonnage of Green Manure Turned Under.

Erosion during two run-off seasons was observed, including the erosion during the year following plowing of the green manure and the year following the first crop after the green manure.

The tonnage of green manure plowed under was grouped in four classes: Light, medium, heavy, and pastured, as previously described.

The degree of erosion was based on the average amount of soil lost per acre from the entire yield as determined by field observation. This information was supplemented by taking actual measurement of soil losses using a modification of the rill method of measurement developed by Alutin.[5]

Four degrees of erosion are established in terms of soil loss. "None" includes those fields which apparently lost no soil; "slight" includes fields on which from 1 to 2.9 tons per acre were lost; "moderate" includes fields which lost from 3 to 5.9 tons; and "severe" includes fields which lost 6 tons or more. This classification of degree of erosion will be used throughout the paper.

The tonnage of green manure plowed under apparently had little effect on the degree of erosion resulting in the first erosion period after plowing the green manure. A very pronounced effect, however, was shown in the degree of erosion during the second period after plowing. A majority of the fields on which light or medium tonnage of green manure was plowed eroded moderately or severely; whereas most of those fields on which heavy tonnages were plowed and on which the sweet clover was pastured showed none to slight erosion. In fact, only 15 percent of the heavy tonnage and pastured sweet clover fields suffered severe soil losses in the second erosion season.

These results must be tempered by the fact that many of the light and medium tonnage fields were also finely pulverized and that the stubble was at least partially burned prior to the run-off period.

Erosion as Affected by the Inclusion of Grass With the Sweet Clover.

A comparison was made of the relative erosion-resisting effectiveness of sweet clover alone as compared to sweet clover and grass in the rotation.

A mixture of grass with sweet clover was slightly more effective in controlling erosion during the first run-off

[5]Alutin, A. N. Unpublished material. Soil Conservation Service, Region 9, U. S. Dept. of Agri.

period after plowing the green manure than was sweet clover alone. None of the fields on which a mixture was plowed eroded more than slightly, but 13 percent of the fields having sweet clover alone plowed for green manure eroded moderately and severely.

The effect of the grass was even more pronounced during the second erosion periods. Nearly 90 per cent of the fields on which a mixture with grass was plowed showed none to only slight erosion; whereas only 37 percent of the fields on which sweet clover alone was plowed showed none to slight erosion, and 63 per cent showed moderate and severe erosion.

Erosion as Affected by the Intensity of Tillage and Resultant Soil Pulverization.

A finely worked surface after the first grain crop seemed to be conducive to more serious erosion than was finely worked green manure land. The same comparison held true for the medium class of pulverization.

Soil pulverized to a fine surface condition eroded severely. Soil pulverized to a medium condition suffered slight and moderate erosion, except where the stubble was burned, in which case it eroded severely. A rough soil surface usually provided complete erosion control, though a few cases of moderate and severe erosion were found on rough tilled fields. In these cases, the stubble had been burned prior to the tillage operation.

Although the degree of soil pulverization markedly influenced the erosion after the green manure, it was more important in combination with residue utilization as a contributing factor to soil loss after the first wheat crop.

Erosion as Affected by Fall Utilization of Residues From the First Wheat Crop After Sweet Clover.

Three classes of utilization were determined. The classes are: Completely utilized, one-half or more utilized, and less than one-half utilized.

Completely utilized stubble was very effective in controlling soil loss. Burning of residues, **even only partial burning,** resulted in severe erosion.

Standing stubble allowed only slight soil losses by erosion.

Completely utilized stubble on plowed fields resulted in 13 percent of the fields' showing no perceptible soil losses, 70 percent showing slight soil losses, 13 percent showing moderate soil losses, and only 4 percent of the fields showing severe soil losses.

All plowed fields on which less than one-half of the stubble was burned showed moderate and severe losses; 43 percent were moderately eroded, and 57 percent were severely eroded.

Plowed fields on which more than one-half of the stubble was burned were almost uniformly severely eroded. Eighty-six percent eroded severely, and the other 14 percent eroded moderately.

The method of utilization did not seem to be as important as the degree of utilization in conserving soil. This study is not sufficiently conclusive at this time, however, to make any definite or final statements concerning this point.

An outstanding effect from the utilization of crop residues was the improvement in tilth of the topsoil. On fields where the residues were burned, extreme puddling and baking occurred in addition to severe soil losses. On those fields where the stubble was utilized, an open, friable condition existed after the run-off period.

Conclusions.

This paper discusses only preliminary data and covers only one crop year and two erosion seasons within a six-year rotation.

The use of sweet clover or sweet clover and grass, when supported by rough or semi-rough surface soil conditions and surface utiizlation of all crop resi-

dues, minimized erosion and markedly increased grain yields. The use of sweet clover or sweet clover and grass in combination with intensive tillage to pulverize the soil increased the yield of the first crop following the green manure, but only at the price of subsequent serious soil losses and undesirable physical condition of the soil. The use of sweet clover or sweet clover and grass in a system wherein crop residues are burned, produced a soil condition in terms of tilth and erosion which was comparable to soil conditions in a wheat-fallow system. The condition may be even more undesirable, because the nitrogen made available by the leguminous green manure may serve as a stimulating influence to the breaking down of soil humus.

The superiority of sweet clover and grass over straight sweet clover was evident from both the soil productivity and the erosion control standpoints.

A Hint Concerning a Mystery—Homing Salmon*

By THOMAS LARGE
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The saving of the salmon of both the Atlantic and Pacific Oceans has become a question of conservation of first rate order. The Atlantic salmon in the North Sea and the Baltic and on the East coast of the United States and Canada is largely a question of a valuable sport fish. That of conservation of Pacific salmon (several species of **Oncrhynchus** and the Steelhead, a Pacific representative of the Atlantic salmon) is chiefly food fish and a commercial asset, but with a growing valuation as a sport fish.

Their threatened extinction by dams has called attention of the public in general to them. Among the old questions which have been raised is that of the "homing" of the salmon in the streams. How does it find its way back? Young salmon of either coast and either genus probably receive little or no attention from their parents. Oncorhynchus are born orphans, hatching frequently in the spring following the death of their parents.

For about four decades leading writers, including among others Jordan, Gilbert and Evermann, have given attention to the return of these salmon when mature. By "The Parent Stream Theory" the mature salmon was postulated to return to the stream in which its parents had lived. By "The Home Stream Theory" mature salmon would return to the stream in which they were hatched or planted. Modern fish-culture methods and planting of eggs or young fish in streams thousands of miles from that in which their parents lived has led to the acceptance of "The Home Stream Theory." This has disposed of the idea that in some way an instinct has through countless generations established a guidance within the fish which would lead them with more or less certainty to the haunts of their parents.

Fish from Alaskan eggs planted in Oregon resulted in return to streams where planted. This established "The Home Stream Theory" on a satisfactory basis but it has left the question of guidance of returning mature fish to this home stream as little understood as the presumed instinct in the other case. There have been many theories to explain this. Oxygen content of the water; carbon dioxide content of the water; the hydrogen ion concentration of the water; temperature of the water, have all had their proponents.

The various questions of conservation and of theory led to a succession of conferences culminating in that of December, 1938, in Ottawa, Canada, in connection with the meeting of the A. A. A. S. This Ottawa symposium now appears as a publication of the A. A. A. S. in book form, and is of extremely high value to all interested in these questions. While it presents several theories for the explanation of the return of the salmon, none is definitely shown to positively prevail.

For the foregoing reasons the writer offers to contribute his bit to the confusion, with the vague hope that it may start investigators on a more fruitful venture: Observations of the writer in July and August, 1931, of the spawning habits of **Oncorhynchus tschawytscha** (Chinook salmon) in the upper waters of the Imnaha River in northeastern Oregon gave the following meager facts: (a) A young male salmon six inches in length, precociously developed sexually, was taken "running milt" near the

*Field work mentioned in this paper was made possible by a grant-in-aid by the National Society of the Sigma Xi.

spawning grounds. (b) Mingled with the usual gallery of bull-trout which are known to accompany the spawning salmon, were observed a considerable number of young male salmon, twenty to thirty inches in length, together with the adult males which approximate forty inches in length. (c) These young males apparently watched their chance to slip in below the spawning female as she extruded the eggs in the convulsions of spawning. They seemed to annoy the adult males greatly, which adults spent no small part of their time tryng to chase them away, which operations only increased the opportunity of the young males to take part in fertilization of the eggs as they floated down to the basin which had been excavated in the stream bottom. (d) To the gorging bull-trout practically no attention was given by the adult males and with good reason, because the number of eggs produced by a single female would be vastly more than a much greater school of bull-trout could possibly eat. (e) Lack of attention by adult males to feasting "bull-trout" indicated other reasons for their annoyance at the young males.

These meager observations if supported by observations of others, or, by careful study of future observers, seemed to the writer sufficient to indicate as a significant fact that (a) the entire hatch of males of any year does not accompany their sisters on their feeding migrations at sea, but that many may remain near the river mouth to accompany the females of broods of earlier years in their spawning migration to fresh water; (b) these philandering young males may guide the incoming mature females and their retinue to the spawning ground. If this is true the question of guidance is simplified to a matter at least no more difficult than that of migrating birds, as ducks, geese, swans, etc.

Also, if this is true, the migrating populations of the Pacific salmon differ from such populations of Atlantic salmon only in that immature females alone are absent from the migrating schools. In this respect, as is so well known in the rivers of England, Scotland, Canada and the United States that particular names have been given to different age groups (Alevin, Parr, Smolt, Grilse, Virgin, Maiden and Kelts).

When an experienced salmon-hatchery superintendent was told of these observations he was not at all surprised and merely remarked, "Jack salmon," indicating that the observed facts were already familiar to him. The writer has had no opportunity to extend his study of salmon spawning to other localities, nor to other species of the Pacific salmon than the Chinook **(O. tschawytscha).**

Recent Advances in the Control of the Common Cold

By HOWARD W. LUNDY, Dr. P. H.
Department of Bacteriology and Public Health, State College of Washington

Due principally to the work of Dr. A. R. Dochez and his associates at Columbia University it is now generally accepted that the majority of common colds are initiated by a filterable virus. The virus porduces an inflammation for several days and as a result of its action certain bacteria that are normally present in the nose and throat are stimulated so that they are able to cause disease.

Most of the symptoms of the common cold and all of the complications are caused by these stimulated bacteria but it is the filterable virus which really starts the infection and it is the virus that is most communicable from one person to another. It is believed that most colds are spread from one person to another through coughing, sneezing, kissing and other such close contacts. The most important single procedure in both the treatment of the cold and the prevention of the spread of the disease is for the patient to go to bed as soon as the symptoms appear and to stay there for two days. By doing this he will shorten the disease, avoid complications and will not spread the infection to anyone else.

In an epidemiological survey conducted among school children in Boston the writer found that only 17% of the students who were absent due to a cold recognized that they had had a "contact" as described above. This means that, in most cases, we do not realize when we are being exposed and must depend on those who have the disease not to give it to us.

The importance of droplet infection in the spread of the disease was borne out by results which showed that those children who had colds reported twice as many "contacts" as did those who did not have colds. However, unusual fatigue and prolonged chilling seemed to play a part in producing colds. This study confirmed others in finding that cold vaccines, vitamins and the diet appeared to have no demonstrable effect in preventing colds.

It has been inferred in the literature that certain inclusion bodies occurring in the epithelial cells of the human throat were related to the virus of the common cold. As the result of a two-year study of these bodies in the throats of normal individuals and of those having colds it was concluded by the writer that these inclusion bodies were non-specific and were unrelated to the virus of the common cold. The same conclusions were drawn concerning certain lesions occurring upon the chorio-allantoic membrane of the chick embryo as it was found that these same lesions could be produced artificially as well as when the virus of the common cold was inoculated.

The most promising line of work at the present time seems to be that being carried on by Dr. Dochez. This is the production of a vaccine by growing the virus on chick embryos with the hope of immunizing people against colds just as we now vaccinate against smallpox. Probably more than one strain of the virus will be used in preparing the vaccine.

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The Washington Blanket Primary*

By CLAUDIUS O. JOHNSON
State College of Washington

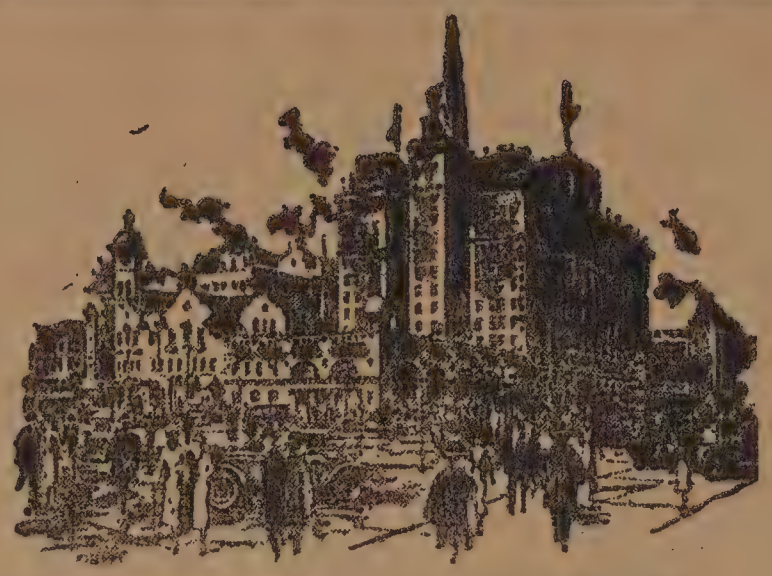
The Washington blanket primary law is an extension into the primaries of the right of independent voting which the electorate of the State has long practiced in the November elections. If independents and those only mildly partisan pick and choose among the candidates of the two parties in the general elections, why should they not have the same privilege in the primaries? If they vote for the man and not for the party in November, why should they not vote for the nomination of the best man, regardless of party, in September? The Washington State Grange said there was no argument against taking this step and it presented us with the blanket primary. To be sure, the law was enacted by the Legislature, but there is no doubt that the Grange initiative brought this action from the Legislature.

Let no one doubt that the voters have used the blanket primary as its promoters hoped they would. In 1936, Republicans by tens of thousands came into the Democratic gubernatorial primary. Democratic candidates for governor received 402,699 votes, while Republican candidates received only 100,498 votes. Do Democrats outnumber Republicans in this State by the ratio of 4 to 1? The votes for aspirants for nomination to other offices give a negative answer. The Democratic primary vote for offices other than that of governor was not quite twice the Republican vote. Again, votes in the general election show that the 4 to 1 proportion is wrong. Martin won the governorship over Hartley in proportion of 2½ to 1, and the other Democrats won by smaller proportions. It is therefore perfectly clear that Republicans, in wholesale lots, supported Democratic candidates for governor in the primaries, and it is a matter of common knowledge in this State that these Republicans supported Martin.

The results in 1936 were satisfactory to conservatives of the State, and one has heard very little complaint about the blanket primary since the autumn of that year. But suppose some "radical" Republicans, Democrats, and others should combine and nominate a candidate as Martin was nominated in 1936. My guess is that the blanket primary would lose many of its friends and would be quite likely to lose its life. We should bear in mind, however, that the blanket primary is in its infancy and draw no conclusions, except purely tentative ones, at this time.

---

*Abstract of paper read before the Social Science Section of the Northwest Scientific Association, December 27, at 2:00 p. m.



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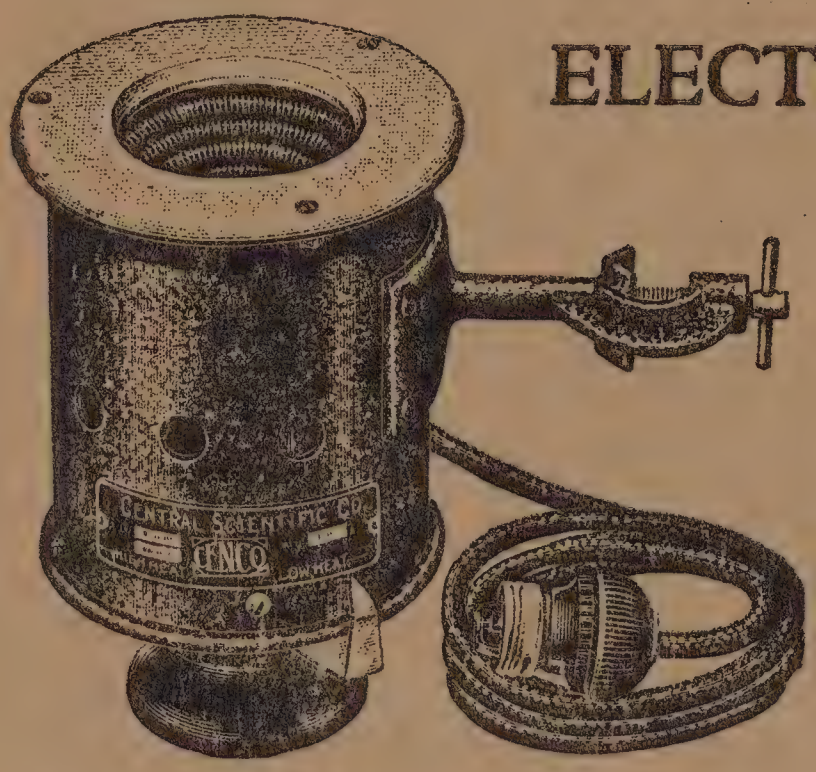

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Geology at the Association Meeting and Plans for 1940 Symposium on Columbia Plateau

By CHARLES D. CAMPBELL
State College of Washington
Acting Secretary, Geology-Geography Section

In this issue of "Northwest Science" are gathered some of the papers and abstracts of papers presented at the Geology-Geography Section of the December 1939 meetings of the Association. The General Secretary, the Editor, and the current officers of this Section, have agreed to continue the practice of including all articles on geology and geography, presented at the preceding meetings, in one issue of "Northwest Science". It was further agreed that the current secretary for the Section should help the Editor in the publication of this issue, to the extent of reviewing the papers and abstracts submitted for printing.

Every paper presented at last December's meetings is printed here, either in full or in author's abstract, with the exception of Professor Warren D. Smith's paper on Oregon lakes, already printed as the December 1939 issue of "Northwest Science". Included instead is a paper by H. P. Hansen, on paleoecology of a Washington peat deposit; this was not presented in the 1939 meetings.

Columbia Plateau Symposium.

During the year preceding the December 1939 meetings, representatives from the Geology-Geography Section from Washington and Idaho held several informal meetings to plan a symposium, or round-table, to be added to the regular program of papers to be presented at the forthcoming (1940) meetings. Representatives from Oregon were invited to participate. The plan of the symposium was to produce a map, with physiographic subdivisions marked, of the entire Columbia Plateau. This plan is a response of geologists in the Pacific Northwest to a growing dissatisfaction with inaccuracies about Columbia Plateau physiography, as presented in widely-circulated texts. It was thought that conclusions based on thorough discussion by geologists long familiar with the problems would serve

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in the future to correct some of the current impressions about Columbia Plateau physiography.

To this end, it was agreed that trial maps of the Columbia Plateau were to be drafted by representatives of the three states and sent to Otis W. Freeman, of Cheney, for use in making a coordinated map of the whole province. This work was to be done for Washington by members of the Division of Geology of the Washington Department of Conservation and Development; for Idaho by Dr. Alfred L. Anderson and the geoolgy staff of the Department of Mines and Geology, University of Idaho; and for Oregon by Dr. Warren D. Smith of the University of Oregon.

* * *

At the morning session on December 28, 1939, Dr. O. W. Freeman, being unable to be present for the symposium, his paper, concerned with suggestions about Washington's part of the problem, was read by his colleague, Mr. W. B. Merriam. Next, Dr. W. D. Smith described the proposed divisions for Oregon, dwelling at some length on an interpretation of the "horsts" of southeastern Oregon as ramp structures. Dr. A. L. Anderson, now at Cornell University, could not attend, but had sent a paper to be read at the symposium. This paper, read by Mr. Merriam also, supplied the proposed Columbia Plateau subdivisions for Idaho. Neither Mr. Freeman's paper nor Dr. Anderson's are to be published in their original form, as they were written solely as sources of debate, not as finished conclusions.

The afternoon meeting of the symposium opened with the selection of Dr. Warren D. Smith as coordinator of the discussion. Then Mr. S. L. Glover, of the Division of Geology of Washington, presented the outlines of work by the Survey staff on the Columbia Plateau subdivisions, followed by a discussion of this work, and of the three morning contributions.

Mr. V. E. Scheid and Dr. R. L. Lupher pointed out the essential continuity of the Craig Mountain-Blue Mountains piedmont, and of the Seven Devils-Wallowa Mountain tract across Snake River canyon from Idaho to Oregon; and they suggested that each of these two physiographic features receive but one name in the final map.

Dr. J. E. Upson and Dr. Lupher proposed that surface features of the Columbia Plateau be used as the basis for the major divisions, and that structures be considered only where they produce irregularities within a major division.

Mr. Stuart Twiss pointed out that at least sixteen different criteria had been offered as bases for subdivision of the Columbia Plateau.

Dr. W. A. G. Bennett suggested that areas of dissected Columbia Plateau basalt in southern Stevens County be given a special name parallel to Flint's "Okanogan Plateau" of the Omak Lake area.

Discussion proceeded along lines similar to the above until it became evident that time was far too short for a satisfactory conclusion to the symposium. Therefore, upon general agreement to continue the symposium another year, Dr. Upson was elected chairman for 1940, and it was decided that his duties were to include the following:

1. To collect material already prepared for, and discussed in, the 1939 meeting.

2. To request any new material from the three states participating.

3. In collaboration with Mr. McMacken, 1940 chairman of the Geology-Geography Section, to appoint a committee of residents of the three states to coordinate such material. This committee would be empowered to draft concrete proposals for a unified Columbia Plateau nomenclature, for discussion at the 1940 symposium.

4. To have the proposals of the above committee mimeographed or printed and distributed to participants at least one month before the December 1940 meeting.

Some Miocene Plants From North Central Idaho*

By NORMAN J. GILLETTE
University of Idaho, Moscow, Idaho

In Miocene time northern Idaho and northeastern Washington were covered with a vegetation much different from that of the present time. It had an aspect which more closely resembled our present eastern deciduous forests. One of the earlier studies on the Miocene floras of the northwest was that of F. H. Knowlton[5] in 1925. The floristic study of Knowlton accompanied a geological study of the Spokane region by Pardee and Bryan[7]. These latter authors proposed the name **Latah formation** "for a series of beds, consisting mostly of clay and shale and of fresh water origin that are found near Spokane, Wash., and that contain an abundant middle or lower Miocene flora". These rocks are often overlaid by basalt flows which are also probably Miocene in age.

Pardee and Bryan state that the rock which composed their Latah formation seems to have been derived from volcanic ash, much of which seemed to have been of an andesite type that fell in showers on the region during the period of sedimentation and apparently was deposited in a fresh water lake. Data derived by Upson[8] point to the same conclusions in regard to the nature of the sediments in which the fossils here discussed are found.

A theory of origin of the Latah sediments is described by Kirkham and Johnson[4] as follows:

> Westward-flowing drainage in mature valleys would be obstructed and ponded by lava flows advancing toward the mountains from a generally westerly direction along an irregular north-south front. Sediments brought down from adjacent mountains would be deposited in front of the flows at first, and as the ephemeral lakes rose in level and were filled up by deposition, the lakes would extend gradually to the west. The sediments would also thin to the west. Successive lava flows would result in a succession of similar phenomena, and consequently more than one sedimentary series would occur in the section. The final result should be a succession of lava flows alternating with sedimentary beds which lie partly in front of them, and partly interbedded with them. Thickness and area of the part which lay in front of the lava flows would vary greatly from place to place, but the thickness and extent of that part which became interberred would be more likely to show some uniformity. At all of the Idaho localities, where the relationships are clear, the evidence bears out the postulate.

Kirkham and Johnson state that field evidence in the Idaho localities has persuaded them to stand by this time-honored theory of origin although it was rejected by Pardee and Bryan for the Spokane area.

The original Latah flora as described by Knowlton contained 42 genera and 95 species of which 51 were regarded as new to science. All specimens examined were from the vicinity of Spokane, Washington and Coeur d'Alene, Idaho. In 1928 Berry[2] revised the flora of the Latah formation and added 57 species and 33 genera. In this latter paper fossils from an additional locality, Stanley Hill, two miles northeast of Coeur d'Alene, were studied.

In the last ten years investigators have reported other localities from which fossils assumed to belong to the Latah formation can be obtained. Kirkham and Johnson[4] list forty such localities within an area approximately 175 miles long and 75 miles wide. Although they include no descriptions of species, they do enumerate species that had not been reported from the Spokane localities. In 1932 Ashlee[1] published the results of his studies on some of the Latah formation in Idaho, and in this several species were added to those already listed by Berry, Knowlton, and Kirk-

*Research aided by a grant from The Northwest Scientific Association.

ham and Johnson. Olson[6] has enumerated several fossil localities in north central Idaho in Latah, Nez Perce, Clearwater, and Idaho counties. Most of these he infers are Latah in age and the majority of these are the same as listed previously by Kirkham and Johnson.

In 1936 Brown[3] published in the United States Geological Survey "Additions to some fossil floras of the western United States". This paper represents a partial revision of the floras represented in the collections of the United States Geological Survey and the United States National Museum. He has proposed many changes in the nomenclature of Knowlton, Berry, and others in the belief that these changes "express a more accurate taxonomic disposition of the species involved". Although Brown's study represents mainly a revision of nomenclature as far as the Latah of Spokane is concerned, seven new species from this region have been described. Several new genera have been added as the result of these synonymy studies.

The materials used in this study were obtained from road cuts along the highway between Juliaetta and Arrow Junction in Nez Perce County, Idaho. One locality (Kirkham and Johnson's station 27(?)) is approximately five miles south of Juliaetta, and a second is five miles farther on toward Arrow Junction (Figure 1). Both localities are on the right side of the highway.

Thus far in this work 35 genera, 42 species in 22 families of Spermatophyta have been recognized from these localities. Some specimens of Bryophyta and club mosses also have been found, but these have not been placed in any genus. Of the seed plants, none of the following genera was mentioned by Knowlton, Berry, Kirkham and Johnson, and Ashlee: *Abies, Picea, Thuites, Carya, Cedrela, Maytenus*(?), *Fraxinus, Vitis, Zelkova,* and *Philadelphus.* (Some of these are the result of Brown's changes of the nomenclature of Knowlton and others.) In addition to the above genera, the following species are new to the Latah flora: *Amelanchier dignatus* (Knowlton) Brown, *Acer septilobatum* Oliver, *Umbellularia oregonensis* Chaney, and undetermined species of *Sophora* and *Nyssa.* Besides these there are several leaves which as yet are unidentified with any available descriptions of western Miocene plants. Some of these doubtless will prove to be new genera for this area. In addition it has been impossible to identify numerous twigs, seeds, and fruits.

Figure 1. Second locality, 10 miles south of Juliaetta, Idaho. Sediments here are tilted.

The flora may be divided into three groups on the basis of distribution of the living equivalents, namely: (1) An eastern Asiatic element, (2) an eastern North American element, and (3) a western North American element.

THE ASIATIC ELEMENT:

Fossil Species.	Living Equivalents.	Distribution.
Alnus relatus	*Alnus japonica*	Japan
Betula fairii	*Betula luminifera*	China
Zelkova oregoniana	*Zelkova ulmoides*	Southwestern Asia
	Zelkova serrata	Japan
Hydrangea bendirei	*Hydrangea strigosa*	China
Sapindus oregonianus	*Sapindus mukorossi*	Eastern Asia
Viburnum lantanafolium	*Viburnum dilatatum*	Japan
	Viburnum erubenescens	China
	Viburnum lantana	Southeastern Asia and Europe

THE EASTERN AMERICAN ELEMENT:

Taxodium dubium	*Taxodium sp.*	Southeastern U. S. and Mexico
Carya egregia	*Carya ovata*	Eastern N. A.
Ostrya oregoniana	*Ostrya virginiana*	Central and eastern U. S.
Magnolia dayana	*Magnolia acuminata*	Eastern N. A.
Liquidambar californiaum	*Liquidambar styraciflora*	Eastern U. S.
Nyssa knowltoni	*Nyssa aquatica*	Southeastern U. S.

THE WESTERN AMERICAN ELEMENT:

Torreya bonseri	*Torreya californica*	West coast
Sequoia langsdorfii	*Sequoia sempervirens*	West coast
Alnus carpinoides	*Alnus tenuifolia*	Western states
Philadelphus pardeei	*Philadelphus lewsii*	Northwestern states
Acer septilobatum	*Acer circinatum*	West coast
Fraxinus denticulata	*Fraxinus oregona*	West coast

In addition to these there are some species whose living equivalents are fairly widespread, at least in the North Temperate zone.

THE COMPOSITION OF THE FLORA

Taxaceae
Torreya bonseri
Pinaceae
Abies sp.
Picea sp.
Pinus spp. (seeds and cone scales)
Sequoia langsdorfii (Brongniart) Heer
Taxodium dubium (Sternberg) Heer
Thuites sp.
Typhaceae
Typha (?) sp.
Salicaceae
Populus heteromorpha Knowlton
Populus fairii Knowlton
Juglandaceae
Carya egregia (Lesquereux) LaMotte
Betulaceae
Alnus corallina Lesquereux
Alnus carpinoides Lesquereux
Alnus relatus (Knowlton) Brown
Betula fairii Knowlton
Ostrya oregoniana Chaney
Fagaceae
Castanea orientalis Chaney
Fagus sp.
Quercus simulata Knowlton
Quercus payettensis Knowlton
Ulmaceae
Zelkova oregoniana (Knowlton) Brown
Ulmus sp. fruit.
Lauraceae
Umbellularia oregonensis Chaney
Magnoliaceae
Magnolia dayana Cockerell

(Drawings reduced about ⅓ in diameter from originals.)

PLATE I.

Fig. 1—*Vitis washingtonensis* (Knowlton) Brown.
U. I. Botany collection No. 100.

Fig. 2—*Fraxinus denticulata* Heer. U. I. collection No. 101.

Fig. 3—*Acer septilobatum* Oliver. U. I. Botany collection No. 102.

Fig. 4—*Philadelphus pardeei* (Knowlton) Brown.
U. I. Botany collection No. 103.

Fig. 5—*Umbellularia oregonensis* Chaney. U. I. Botany collection No. 104.

Fig. 6—*Zelkova oregoniana* (Knowlton) Brown.
U. I. Botany collection No. 105.

Fig. 7—*Maytenus* (?) sp. cf. *M. phyllanthoides* Bentham.
U. I. Botany collection No. 106.

Fig. 8—*Carya egregia* (Lesquereux) LaMotte. U. I. Botany collection No. 107.

Saxifragaceae
Hydrangea bendirei (Ward) Knowlton
Philadelphus pardeei (Knowlton) Brown
Hamamelidaceae
Liquidambar pachyphyllum Knowlton
Liquidambar californicum Lesquereux (fruit)
Rosaceae
Amelanchier dignatus (Knowlton) Brown
Leguminosae
Cercis spokanensis Knowlton
Sophora spokanensis Knowlton
Meliaceae
Cedrela pteraformis (Berry) Brown
Celastraceae
Maytenus (?) cf. *phyllanthoides* Bentham
Aceraceae
Acer septilobatum Oliver (fruit)
Acer sp. (leaf)
Sapindaceae
Sapindus oregonianus Knowlton
Vitaceae
Vitis washingtonensis (Knowlton) Brown
Cornaceae
Nyssa knowltoni Berry
Oleaceae
Fraxinus denticulata Heer
Caprifoliaceae
Viburnum lantanafolium Berry
Incertae Sedis
Carpites boraginoides Knowlton

CONCLUSIONS

The plants listed above from the two localities in north central Idaho indicate Miocene age and probably Latah. Whether these are older or younger than the Latah of Spokane, the writer is not prepared to state at the present time.

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Abstract

Pegmatite Minerals at the Kettle Falls of the Columbia

By CHARLES D. CAMPBELL
State College of Washington

A granitic pegmatite sill in the quartzites forming Kettle Falls swells to over ten feet in thickness, and pinches out to zero, the variations being irregular. Its minerals, in decreasing order of abundance, are orthoclase, quartz, albite, muscovite, tourmaline, garnet and beryl. The larger orthoclase crystals are six-inch ovoids, locally perthitic. These and the smaller crystals are coated with creamy albite which has turned crumbly with weathering. Gray vitreous quartz forms small irregular masses, and a later generation cuts all other minerals. Muscovite books up to two inches across are imbedded in the feldspars. Small black prisms of tourmaline are clustered locally; many are cracked and then healed with late quartz. Red trapezohedral garnets occur in most places; and in one nest near the east end of the lower falls, crystals over an inch in diameter were found. A few small pale-blue beryl crystals occur in a north-facing wall upstream from the large garnets. Only the late quartz, in fragile veinlets, is thought to be of later date than the deformation which strained, cracked and granulated the other minerals.

Significance of a Fossil Horse Tooth Found at Moscow, Idaho[1]

By VERNON E. SCHEID

Late in June, 1939, a lower cheek tooth of a horse was uncovered while digging the foundation for the Signal Oil Station at Main and 8th Streets, Moscow, Idaho. It was found about four feet below the surface. The earth surrounding the tooth was undisturbed and was identical in all characteristics with the "Palouse"[2] formation, as it is exposed in road cuts throughout the surrounding country.

The tooth (Fig. 1) is a lower left cheek tooth—whether a molar or premolar it is impossible to determine. When dug up, it was complete but the lower portion of the anterior root broke off later. The tooth is large and heavily cemented, so that the upper portion of the buccal surface slopes inwardly toward the grinding surface. The cement is lightly striated vertically and shows flat, horizontal, irregular bulges on the upper one-third of the buccal surface of the crown. As viewed from the posterior the tooth shows a slight curvature; the outer side being convex. All sides of the tooth are somewhat vertically grooved; the buccal side distinctly and the labial side very pronouncedly. An unusual feature of the section shown by the grinding surface is the small, oval conulid (see "a" of Fig. 1) near the middle of the anterior surface. Measurements of the tooth are recorded as follows:

Anteroposterior length	33 mm.
Transverse width	23 mm.
Height (vertical length)	75 mm.
Height of Crown	44 mm.

The tooth was examined by Dr. C. L. Gazin, U. S. Nat. Museum who writes[3] "that it seems to be very near the form Equus idahoensis. It is fully as large as in E. idahoensis but differs from this species in exhibiting a somewhat more modern pattern. I have no hesitancy, however, in regarding the specimen as of Pleistocene age rather than Recent."

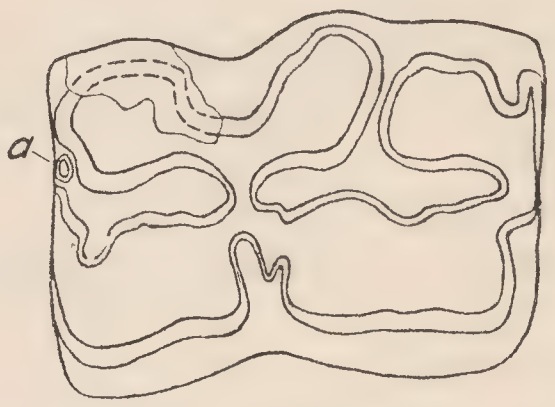

Fig. 1. Grinding surface of horse tooth from the "Palouse" formation, Moscow, Idaho. Natural size.

Fossils are practically unknown from the "Palouse" formation throughout the "Palouse country" of eastern Washington and the adjacent portions of Idaho. This fact lends added importance to the Moscow horse tooth as a clue to the age of the sediments. As noted above from a letter by Dr. Gazin, the tooth is near but apparently younger than E. idahoensis, which was first described by Merriam[4] from the Idaho formation. This formation has been studied and correlated by several workers. Merriam writes[5] that the Idaho formation "contains a fauna of a stage representing either the latest Pliocene or the earliest Pleistocene". Kirkham in his revisional study agrees[6] with Merriam. But Hay[7] would restrict the formation to the Pleistocene and suggests that the contained fauna "may justify the reference of the deposits to some part of the Nebraskan stage". Thus, it seems well established that the Idaho formation is early Pleistocene bordering on late Pliocene. The new species, Equus idahoensis, would of course have the same age. On the basis of the more modern enamel pattern, the horse tooth from Moscow may be considered at least slightly younger than E. idahoensis and therefore of post-Nebraskan age; if Hay's correlation of the Idaho formation is to be accepted.

An upper limit to age of the tooth is

not so easily obtained and can only be estimated after considering the geology of the "Palouse" formation. Since its definition by Treasher[8] the validity of the "Palouse" as a single formation and its position in the geologic column has been questioned by several workers. Treasher, himself, pointed out that the formation was composed of two phases: (1) a lower, well stratified and thinly-bedded loess and (2) an upper, massive silt formed from reworked material of the lower phase. Above both phases is the present fertile soil of the "Palouse country"; this Treasher considers to be a residual modification of the two underlying phases.

Most other workers have also recognized two phases in the "Palouse" formation. Bryan's study[9] nicely summarizes the known geologic and physiographic data of the formation. He also recognized two phases: an older phase, which composes the inner core of the Palouse hills and a younger phase above it. The older phase is composed of several types of sediments; including a well weathered and compacted glacial till. The younger phase is a thin veneer, 3 to 10 feet deep of loessial soil. The younger or upper phase was established by him as older than the Spokane glacial stage and younger than the "early" glacial stage of Bryan; the till of which, as previously noted, is contained in the older phase of the "Palouse" formation. This places the age of at least a part of the older phase as that of the contained glacial till which with the elephant bones[10] uncovered by Bryan caused him to consider the age of the older phase of the "Palouse" formation to be "pushed far back into Pleistocene time"[11]. More recently Culver[12] has argued that the "Palouse formation is an extension of the Ringold[13] formation of central Washington. He would restrict the term "Palouse" formation to mean only the agricultural soil of the "Palouse country"; that is, the surficial material, a few feet thick, formed as a reworked modification of the underlying "Palouse" or Ringold formation. Merriam and Buwalda[14] consider the Ringold formation to be Pleistocene rather than the latest Pliocene and imply that they favor the lower Pleistocene. If by extension this is accepted as the age of the formation at Moscow, it is seen to be near that of the Idaho formation of southwestern Idaho. However, whether the tooth was lodged in the upper or lower phase of the "Palouse" formation is not known. As shown by Bryan the upper phase of the "Palouse" formation is older than Spokane till but younger than still another but undated till contained in the lower phase.

Thus the determination of the exact age of the formation containing the horse tooth at Moscow must await additional evidence. Its geological location quite clearly places it as older than the modern, residual, reworked, surface soil (Palouse of Culver) that furnishes the fertility of this region. From admittedly scant paleontological evidence the formation is younger than Nebraskan and even if it should prove to be the upper phase of the "Palouse" formation, physiographic and geologic studies of similar deposits throughout the "Palouse country" have shown it to be older than the Spokane glacial stage. These limits suggest middle or lower middle Pleistocene time as the age of at least a part of the "Palouse" formation around Moscow.

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[1]Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 27-28, 1939.

[2]Treasher, R. C., Origin of the loess of the Palouse region, Washington: Science, new ser., vol. 61, p. 469, 1925.

[3]Personal communication.

[4]Merriam, J. C., New mammalia from the Idaho formation: California Univ., Dept. Geology Bull., vol. 10, pp. 523-530, 1918.

[5]Merriam, J. C., Relationships of Pliocene mammalian faunas from the Pacific Coast and Great Basin provinces of North America: California Univ., Dept. Geology Bull., vol. 10, p. 432, 1917.

[6]Kirkham, V. R. D., Revision of the Payette and Idaho formations: Jour. Geology, vol. 39, p. 235, 1931.

[7]Hay, O. P., The Pleistocene of the western region of North America and its vertebrated animals: Carnegie Inst. Washington Pub. 322B, p. 269, 1927.

[8]Op. cit.

[9]Bryan, Kirk, The "Palouse soil" problem, with an account of elephant remains in wind-borne soil on the Columbia Plateau of Washington: U. S. Geol. Survey, Bull. 790, pp. 21-45, 1927.

[10]Idem., pp. 34-35.

[11]Idem., pp. 37.

[12]Culver, H. E., Extensions of the Ringold formation: Northwest Sci., vol. 11, pp. 57-60, 1937.

[13]Merriam, J. C., and Buwalda, J. P., Age of strata referred to the Ellensburg formation in the White Bluffs of the Columbia River: California Univ., Dept. Geology Bull., vol. 10, pp. 255-266, 1917.

[14]Idem., p. 260.

Reverse Versus Thrust Faults

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This note arises from a desire to urgently caution against the ambiguous employment and false interpretation of the word "thrust" in the geometric description and treatment of all high-angle reverse faults. The indiscriminate usage of "thrust" as a descriptive adjective, with no thought as to what the deforming stresses may have been, has crept into geologic literature and into the mental processes of numerous geologists. For example, in the well-assembled and concisely written text "Geology, Principles and Processes" by Emmons, Thiel, Stauffer, and Allison, which was recently revised (1939), the term thrust and reverse are loosely used. Figure 388 (page 358) illustrates, in geometric description, a normal fault as compared to a reverse fault structure, but the reverse fault has there been unsuitably labeled "thrust". Again, on page 359, it is inferred, if not stated directly, that thrust and reverse have synonymous meanings. Many other references of like nature can be cited, not only from textbooks of geology, but also from current geologic journals and periodicals.

Willis, in defining the terms normal fault and reverse fault, writes as fol lows:[1] "A fault which was the reverse of normal was a reverse fault. These old terms have outlived their usefulness and have gathered a number of misconceptions, but they are so firmly fixed in the nomenclature of geology that they must be continued in use, though we should try to avoid the false interpretations with which they are too often associated."

Regardless of whether high-angle and low-angle may constitute more suitable descriptive terms we are, as Willis believes, probably obliged to continue the use of the words normal and reverse in fault terminology. The fact that geology is not an exact science should not preclude the proper use of terms and descriptions, especially when certain designations have been made and defined. "Geology suffers accordingly, for loose language is the expression of loose thinking and leaves the reader in doubt as to the value of the observations which it records," Willis.[2]

Members of the Geological Society of America early realized the importance of standardization of fault nomenclature. This Society, in an effort to overcome ambiguity and inconsistency in the descriptive treatment of faults, appointed a committee in 1908 to study and formulate principles for the nomenclature of faults. The report of this committee, published in 1913, has become accepted as the authority of fault terminology. Reverse faults are therein defined[3] as fault structures, "Where the hanging wall has been raised relatively to the footwall," and further it is written,[4] "We recommend that the terms **normal** and **reverse** faults as defined be used purely for purposes of description and not for the purpose of indicating extension or contraction, tension or compression, vertical or horizontal forces." Thus it is apparent that the antonym of normal is reverse, certainly not "thrust", which by its connotation primarily suggests compression. In fact, this point is clearly stated by the Committee on Nomenclature where they list, as one of their guiding principles,[5] the desire "to make the classification (of faults) geometric and descriptive, not genetic, in order that a fault may be described so far as it may have been observed without any inferences as to the forces which produced it. For instance a so-called "thrust fault" may sometimes be formed without any compression, and a "tension fault" without any tension; the terms "thrust" and "gravity" faults . . . should only be used after the forces which produced the fault are understood . . . a dynamic system of classification will be in order when the dynamics of faults is better understood."

Because horizontal movement can, under certain conditions, give the appearance of normal or reverse faulting, even though there has been no vertical stress component during displacement, Nevin,[6] in defining a reverse fault, adds the qualifying adverb that the hanging wall has **apparently** moved up with respect to the foot wall. Willis[7] also qualifies normal and reverse fault terminology by the word **apparent**.

If we grant the premise, or at least assume, that the dynamics of faults are better understood today than they were in 1913, then still further evidence presents itself in support of the contention that "thrust" should not be used in lieu of, or interchangeably with, the term "reverse." Studies of the dynamic relations and the stresses involved in the formation of numerous horst structures indicate that, in many instances, these block like forms have been produced by actual uplift of the block; that is, by vertical uplifting stresses or central "up thrust" adjustments. If the faults which delimit the horst are the normal type, as is frequently the case, then the term "thrust" can be used conveniently to describe the manner of stress causing the resulting fault ridge even though the adjacent faults are of normal type. The particular structures should then be properly called thrust[8] normal faults. When the associated faults are reverse, and the center portion has been proven to be actively "up thrust", then the component structures, which bound the area, may be described as thrust reverse faults.

If "thrust" has a place in geologic terminology, that place is in the treatment of stress relations or in the presentation of dynamic principles. Webster[9] defines the geologic use of thrust as, "a compressive tangential stress in the earth's crust or the effect of such a stress; a thrust fault." Although a thrust fault is therein[10] given as, "when the angle between the horizontal and the plane of a reverse fault is small the fault is a thrust fault or an overthrust fault," this employment of thrust fault is technically not proper even in the geometric description of overthrust or underthrust faults. The term **overthrust** is recommended in lieu of "thrust" by the Committee on Nomenclature[11] when a reverse fault of low dip is being geometrically treated.

To the casual reader the title of this paper may have appeared quite naive. However, the writer is convinced that such a reaction, if experienced; was not directly induced by the title to the degree that it was from the widespread improper use of the term "thrust" fault. The foregoing discussion may be summarized as follows:

"Thrust" and "reverse" are not interchangeable in fault description.

The antonym of normal fault is reverse fault.

Low-angle reverse faults are either overthrust or underthrust faults when described geometrically.

"Thrust" should be used as an adjective to describe the fracture when the strain can be determined to have resulted through thrusting stresses.

The point may be raised that such a terminology is confusing and unnecessary. In the writer's opinion, it is certainly less confusing than the lax treatment now prevalent and, in addition, it coincides with the requirement some authors[12] now find for the use of the terms "thrust" or "upthrust".

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[1]Baily Willis and Robin Willis: **Geologic Structures Third Edition,** McGraw-Hill Book Company, Inc., (1934) p. 148.
[2]**op cit.,** p. 214.
[3]H. F. Ried, **et al: Report of the Committee on the nomenclature of faults,** Geol. Soc. Am., vol. 24 (1913) p. 177.
[4]**Ibid.,** p. 178.
[5]**Ibid.,** p. 164.
[6]C. M. Nevin: **Principles of Structural Geology,** John Wiley & Son, Inc., (1931) p. 83.
[7]**Op cit.,** p. 149.
[8]Nevin and Willis both use "upthrust" as perhaps a more suitable term.
[9]**Webster's New International Dictionary of the English Language Second Addition unabridged,** G. and C. Merriam Company (1936) p. 2638.
[10]**Op cit.,** p. 924.
[11]**Op cit.,** 5, p. 179.
[12]C. M. Nevin: **op cit.,** p. 106.
Baily Willis and Robin Willis: **op cit.,** p. 225-227.

Paleoecology of a Montane Peat Deposit at Bonaparte Lake, Washington

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This study is concerned with fossil pollen analysis of a montane, post-Pleistocene peat deposit in north central Washington. The specific location is at the north end of Bonaparte Lake in Section 9, T. 38 N., R. 30 E., on the Osoyoos Quadrangle in Okanogan County, Washington, about 15 miles south of the Canada border. This area lies within the boundaries of Pleistocene glaciation which is in general correlated chronologically with the Wisconsin stage of the upper Mississippi Valley region (Flint, 1935). Bonaparte Lake is situated in the valley and near the headwaters of Bonaparte Creek which flows southwest, then west, and finally northwest to empty into the Okanogan River. The lake was apparently ponded by a terminal moraine or glaciofluvial sediments. Several small kettle ponds exist a short distance above the lake, while downstream the valley floor is largely covered with a sedge-meadow for several miles. The north and south margins of the lake are being encroached upon by hydrarch plant succession, but the lateral shores are steep and rocky and show little evidence of bog formation. The elevation of the lake is about 3600 feet above sea level. The surrounding area is exceedingly rugged, with steep slopes rising immediately to the east and west of the lake. Mt. Bonaparte, several miles to the west, is the highest peak in the vicinity and reaches an altitude of 7280 feet. The area lies near the western edge of the Northern Rocky Mountain physiographic province (Fenneman, 1931), and is usually spoken of as the Okanogan Highlands.

Forests in Adjacent Areas.

The peat deposit is located within the Canadian Life zone, which occupies a small, isolated area in this region because of its higher elevation than the surrounding area (Piper, 1906). The upper slopes of Mt. Bonaparte support the Hudsonian, surrounded by the Canadian zone. These are encircled by the Arid Transition (timbered) zone, which grades into the timberless portion of the same zone near the Okanogan River about 30 miles to the west. The timberless Arid Transition in turn grades into the Upper Sonoran Life zone in the Okanogan Valley. The combined area of the Canadian and Hudsonian zones is slightly greater than a township, with the peat deposit situated near the northeastern edge. Thus, three life zones exist in close proximity to the peat deposit, and are recorded therein by the pollen from their forests. The timbered Transition zone, however, comprises by far the largest part of this region.

The Canadian Life zone in the state of Washington is not well defined, but western white pine (*Pinus monticola*) is probably more restricted to and representative of this zone than any other tree (Piper, 1906). It is not, however, so abundant as in northern Idaho. In the Okanogan Highlands other conifers present, but not confined to this zone, include Douglas fir (*Pseudotsuga mucronata*), lodgepole pine (*Pinus contorta*), western larch (*Larix occidentalis*), lowland white fir (*Abies grandis*), Engelmann spruce (*Picea engelmanni*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). The Hudsonian, lying just above the Canadian zone, supports sparse forests of subalpine fir (*Abies lasiocarpa*), lodgepole pine, white bark pine (*Pinus albicaulis*), alpine larch (*Larix lyallii*), and mountain hemlock (*Tsuga mertensiana*). The timbered Arid Transition zone is characterized chiefly by western yellow pine (*Pinus ponderosa*) which usually occurs in pure, open stands be-

cause of its intolerance for shade. It is often associated with Douglas fir. Other trees in order of their abundance are lodgepole pine, western larch, lowland white fir, western hemlock, and western red cedar. The latter occurs chiefly on protected sites near stream courses. Broadleaf species which thrive locally on favorable sites in both the Transition and Canadian zones include cottonwood (*Populus trichocarpa*), mountain birch (*Betula fontinalis*), *mountain older* (*Alnus tenuifolia*), late alder (*A. sitchensis*), dwarf maple (*Acer glabrum*), and several species of willow. It is to be noted that lodgepole pine occurs in all three life zones, usually as a disclimax species invading areas that have been disturbed by lumbering and fire.

Clements' classification of the major North American vegetation climaxes includes most of the Okanogan Highlands in the larch-pine association of the coast forest (Weaver and Clements, 1938). Altitudinally, this forest lies between the subalpine zone and grassland formation and includes most of the Canadian and timbered Transition zones. The larch-pine forest is a transition type between the cedar-hemlock formation of the coast forest and the montane forest of the Rocky Mountains. Zon (1924) includes most of the Okanogan Highlands in the yellow pine-Douglas fir forest without differentiating the higher slopes as forested with spruce-fir, which exists immediately above the former on the eastern slope of the Cascades. The bunchgrass prairie adjoins the yellow pine-Douglas fir forest at lower elevations. The yellow pine-Douglas fir forest includes all of the timbered Transition and most of the Canadian zone, while the spruce-fir forest includes the remainder of the Canadian and all of the Hudsonian zone according to Zon's classification.

The ruggedness and relief of the adjacent terrain with its diversity of slope, exposure, soil, and climate, effects the existence of several associations, faciations, and consociations near the bog. This variation of environmental factors is also manifested by a large number of forest types within a relatively small area (Forest Type Map, 1936). Thirteen different forest types exist within a radius of ten miles about Lake Bonaparte. The greatest part of this area is covered with an upper slope type consisting of Douglas fir, white pine, lodgepole pine, western larch, Engelmann spruce, lowland white fir, and an occasional specimen of western hemlock. This type lies adjacent to the east shore and to both ends of the lake. The peat deposit actually is within, but close to the edge of this type. The next most widely spread type is yellow pine which is represented by four size classes. This type, consisting mostly of large trees, forms a zone along the western edge of the lake and then extends north, where it covers the valley. This type has a higher percentage of its component species than the former, and is strongly represented in the upper levels of the pollen-bearing sediments. An extensive area of lodgepole pine type occurs on the higher slopes to the west, and this species is also abundantly recorded in the peat deposit. Douglas fir types of several size classes are of next importance, and this species records next to the highest proportion of pollen in the uppermost horizon of peat. Others of lesser importance and occupying small, isolated areas include subalpine, upper slope, and pine mixture types, the latter usually consisting of up to 50 per cent of yellow pine. Life zones and climax formations indicate in a general way and in broad classifications the existing forests, but forest types point out in greater detail their composition and the relative proportions of the component species.

Climate.

Thornthwaite (1931) in his classification of the climates of North America designates this region as having a subhumid, microthermal climate, with deficient precipitation at all seasons. Thornthwaite's climatic provinces are

based upon the relation between humidity, temperature, and seasonal distribution of precipitation. Small, localized areas with different climate within the larger provinces are not indicated, but if the above climatic factors are known the climatic classification for an area may be computed with certain formulae. It seems probable that the Canadian and Hudsonian zones at higher elevations on the slopes of Mt. Bonaparte would constitute a wetter climatic province than the surrounding Arid Transition zone. The mean annual precipitation at Republic, Washington about 18 miles to the southeast at an elevation of 2650 feet is 14.4 inches. At Irene Mountain, 5 miles to the east at an elevation of 2700 feet it is about 13 inches, and at Lemansky Lake, 22 miles to the west at an elevation of 2500 feet the precipitation is 17 inches. The annual precipitation at Bonaparte Lake is probably at least as much as the latter, as its elevation is 3600 feet and it is well within the Okanogan Highlands. The annual mean temperature at Republic for a period of 26 years is 43.6 degrees.

Characteristics of the Bog.

North of Bonaparte Lake are several kettle ponds, all of which support various stages of hydrarch succession. The summer of 1939 had little precipitation and the more shallow of these ponds were entirely dry. The first pond north was isolated from Bonaparte Lake, although the surface of the peat deposit indicates that the isthmus between the two is inundated most of the year. Near the shore of the lake and pond exists a submerged hydrosere consisting of almost pure stonewort (*Chara sp.*). Farther toward shore a floating hydrosere of yellow pond lily (*Nymphaea polysepala*) and pond-weed (*Potamogeton longchitis*) is present. This is followed in shallow water and on the bog by bulrush *Scirpus validus*), spike rush (*Eleocharis sp.*), cattail (*Typha latifolia*), and water smart weed (*Polygonum amphibium*). On higher ground on the margin of the bog grow mountain alder, mountain birch, and several species of willow, but apparently with no significant zonation.

Peat samples were obtained in several places near the shore of the main lake and the pond with a Hiller peat sampler at quarter meter intervals. The greatest depth noted was 3.25 meters. The organic peat and other pollen-bearing sediments are underlain with sand and gravel, through which the peat sampler was unable to penetrate. The lower meter consists of a whitish-gray

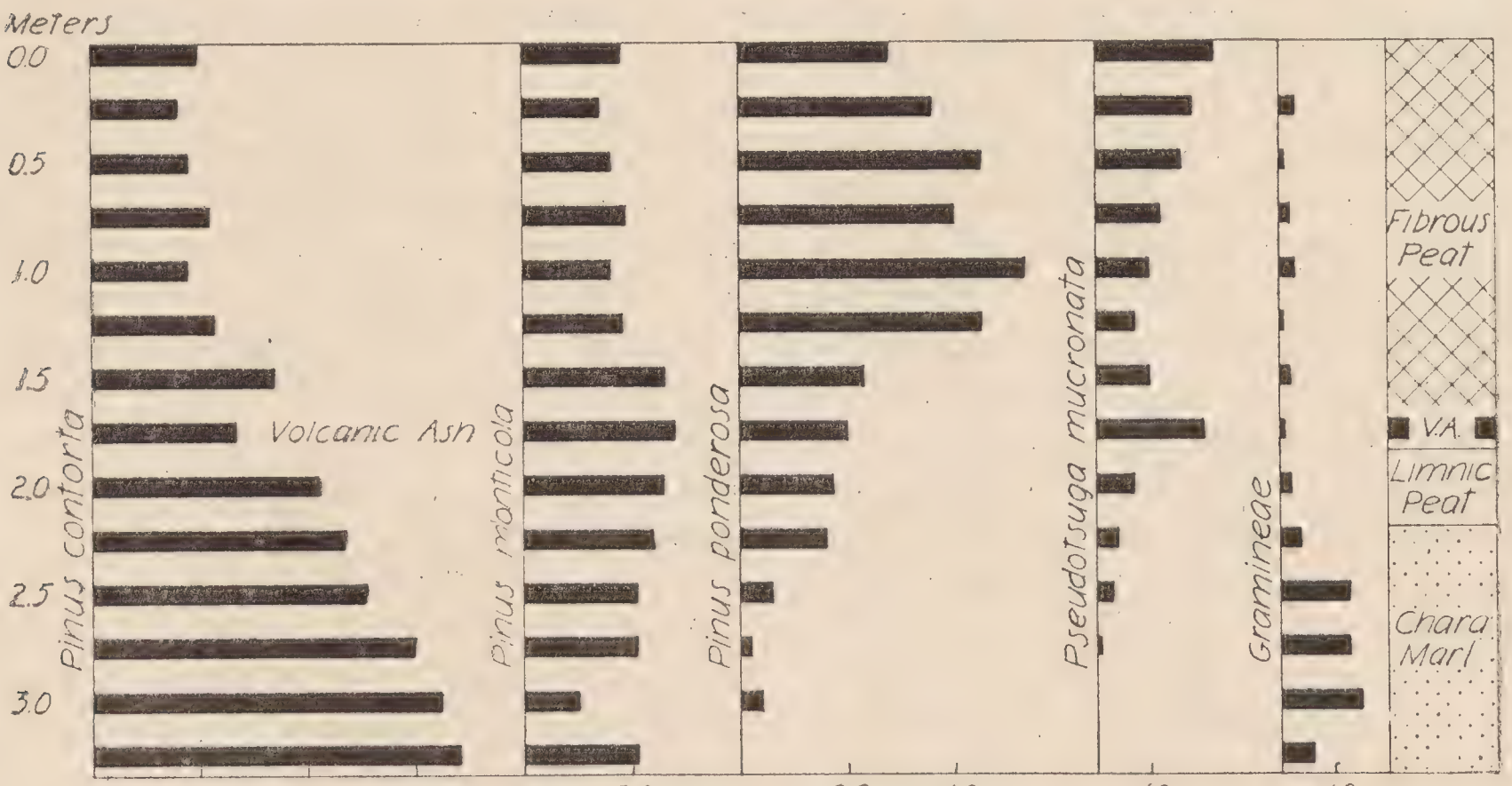

Fig. 1. Pollen Profile, Bonaparte Lake Bog.

marl formed from the remains of Chara which assimilates considerable calcium carbonate. At 2.25 meters this changes into a tannish-gray limnic peat, but with still a considerable amount of calcareous material present. At 1.85 meters this grades into a fine, fibrous peat which is present to the surface. A well-defined layer of volcanic ash occurs at 1.75 meters. Volcanic ash is present in many of the bogs in the Pacific Northwest (Rigg, 1939; Hansen, 1938, 1939a, 1939b, 1939c). In some bogs it occurs as a definite layer, while in others it is present in the form of crystals dispersed vertically through a half meter or more of peat (Hansen, 1940a, 1940b). The stage of hydrarch succession in the lake or on the bog at the time of eruption probably determined whether the ash is preserved as a layer or vertically dispersed. The layer of ash serves as an excellent chronological indicator, and it should be invaluable in correlating post-glacial forest succession as interpreted from pollen analyses of bogs in the several climax formations in the Pacific Northwest. It is presumably from the same eruption or series of eruptions of Cordilleran volcanoes, although a petrographic study would have to be made in order to verify this assumption.

Methods.

In preparation for study, about 2 cc. of peat or pollen-bearing sediment was boiled in a weak solution of potassium hydrate, strained through cheesecloth, centrifuged, washed several times, stained with gentian violet, and mounted in glycerin jelly. In the lower one and one half meter it was necessary to add several drops of concentrated hydrochloric acid in order to remove the calcareous crystals that otherwise obliterated the pollen and made their identification uncertain. The acid apparently had no effect upon the pollen grains, but it did eliminate all of the calcareous material with considerable effervescence. Exactly 150 significant pollen grains were identified from each level. The non-significant pollen was also recorded but not used in the computation of percentages. Non-significant pollen is that from plants which are not ocnsidered to be indicative of adjacent forest succession because of their localized occurrence on or near the bog (table 1). Those species recording less than 1.5 per cent of the total at any level are listed as 1 per cent in the table.

The differentiation of the pollen of *Abies, Pinus,* and *Picea* in the Pacific Northwest seems to present no difficulty. Their identification is based upon the size of the pollen grain, shape and position of the air sac on the cell, and the relative size of the air sac and cell. The separation of the species of *Abies* and *Pinus* is less easy, however, and their identification must be based largely on their size ranges. The following method was used for previous as well as the present study. Two hundred pollen grains of each species were measured and the size range determined. The modern pollen was fossilized with a weak solution of potassium hydrate, and mounted in glycerin jelly in order to simulate the conditions in preparing the peat pollen. This was found to be necessary because of the slight increase in size effected by the action of the potassium hydrate. The separation of the several species of pine pollen is the most difficult, and perhaps more subject to error than the other genera. *Pinus contorta* has the smallest pollen, and because it apparently does not overlap with that of *P. monticola* in size range, its segregation from the others seems to be fairly accurate. The pollen of *P. ponderosa* is larger than that of white pine, but there is some overlapping of their size ranges. The range of *P. albicaulis* is largely within that of white pine, but it also overlaps that of yellow pine. As there seem to be no other distinguishing characteristics, it is impossible to separate this species from the other two. White bark pine, however, is a timberline tree of the subalpine zone, and probably never was

abundant during postglacial time. Pine pollen is far more abundant in bogs east of the Cascade divide than in the Puget Lowland. In the former region the pollen of white, yellow, and lodgepole pine constitutes the bulk of that recorded in the peat, and it is important that these species be separated in order to interpret postglacial forest succession and climate. In the Puget Lowland the pollen of Douglas fir and western hemlock represents the major proportion of the pollen recorded, except in the lower levels where lodgepole pine is usually the most common (Hansen, 1938, 1940a). Yellow pine is restricted chiefly to the east of the Cascades, although it does occur in rare instances on the gravelly, outwash plains near Olympia, Washington.

In Abies the size range of *A. amabilis* overlaps that of both the larger *A. nobilis* and the smaller *A. grandis*, so no attempt has been made to segregate this species. *A. grandis* is probably the most abundant, but it rarely records more than 10 per cent, while the total of fir pollen is seldom more than 15 per cent. *A. lasiocarpa* is the smallest of the fir pollen, but overlaps slightly with that of *A. grandis*. Its separation seems possible, however, by its air sacs which are larger in proportion to the cell than that of lowland white fir. The size ranges of *Picea sitchensis* and *P. engelmanni* overlap slightly, but as far as is known their geographic ranges do not overlap in Washington. The first is recorded in bogs west of the Cascades, while the latter is represented in montane bogs to the east, but not in considerable proportions. No attempt has been made to separate the pollen of *Larix occidentalis* and *L. lyallii*, nor that of *Tsuga heterophylla* and *T. mertensiana*. The latter species of each genus, however, occurs in the sub-alpine zone and are probably not recorded to any great extent in bogs at lower elevations. The pollen of *Pseudotsuga mucronata* is readily identified, but that of *Thuja plicata* apparently is indistinguishable from that of the species of *Chamaecyparis*, *Juniperus*, and *Taxus*. The pollen of these genera is fragile and probably not well preserved in peat.

In identifying fossil pollen, the size of the cell is noted, and if it is within the limits of overlap of other species, distorted in shape, or broken, it is discarded as an unknown. The proportion of significant pollen thus discarded varies from 5 to 12 per cent in this paper, which may or may not tend to invalidate the results of fossil pollen analysis.

Postglacial Forest Succession.

The pioneer, postglacial forests that invaded areas adjacent to the bog, as recorded in the earliest pollen-bearing sediments, consisted chiefly of lodgepole pine with some white pine. These species record 68 and 21 per cent respectively in the lowest level (fig. 1). Lodgepole pine in general seems to have been the chief initial, postglacial invader in glaciated areas of the Pacific Northwest, as is evidenced by pollen analyses of bogs that apparently had their origin soon after the recession of the glacier (Hansen, 1938, 1939a, 1939b, 1940a). In two bogs of which immediate postglacial origin is doubtful, lodgepole pine was not the most abundant conifer represented in the lowest pollen-bearing strata (Hansen, 1939c, 1940b). This suggests that the stage of forest succession may have progressed beyond the initial stage of lodgepole pine invasion, and it also corroborates the geological evidence that some postglacial time had elapsed before the origin of these two bogs. In this study, lodgepole pine gradually decreases to 27 per cent at 1.75 meters, and then fluctuates between 34 and 16 per cent from this level to the surface where it records 20 per cent. White pine decreases to 10 per cent at 3 meters, then gradually increases to 28 per cent at 1.75 meters, and then with slight fluctuation decreases to 18 per cent at the surface. Grass pollen is abundant

in the lower levels, recording 6 per cent at the bottom, increasing to 15 per cent at 3 meters, recording 13 per cent at the next two levels, and then gradually decreasing to negligible proportions throughout the rest of the profile. A similar profile is shown by grass in a montane bog in northern Idaho (Hansen, 1939a), while in a bog near New Westminster, British Columbia, the highest percentage of grass is recorded in the level next to the bottom (Hansen, 1940a. The abundance of grass pollen may indicate the presence of tundra-like conditions which existed for some time upon the recession of the ice. On the other hand, it may suggest an initial grass invasion which was gradually replaced with forest with no climatic significance.

Yellow pine was seemingly absent in the pioneer forests, but appears in the 3 meter level where it records 4 per cent. The next level shows 2 per cent from which there is a gradual increase to 53 per cent at 1 meter, the highest proportion recorded by this species throughout. It diminishes with some fluctuation to 28 per cent at the surface. Yellow pine was the most abundant tree during the time represented from 1.25 meters to the surface. Douglas fir is absent in the lower levels, records 1 per cent at 2.75 meters, increases to 20 per cent at 1.75 meters, slightly decreases to 7 per cent at 1.25 meters, and makes a final increase to 22 per cent at the surface. Other conifers represented in limited proportions are western hemlock, Engelmann spruce, white and subalpine fir, and western larch. The latter is most abundantly and frequently recorded with 10 and 7 per cent in the upper two levels respectively (table I). Broadleaf species present are alder, maple, birch, and willow, with the first two most abundant. The increase in the number of sedge pollen from the bottom to top is correlative with the increase of sedge on the bog in more recent time. Thus, the forests existing in recent time within range of pollen dispersal to the bog, consisted chiefly of yellow pine, Douglas fir, lodgepole pine, and white pine, with their relative abundance in the order named. The proportions of these species as manifested by pollen analysis may be somewhat in agreement with those of existent forests. This is suggested by the distribution of the nearby forest types, and a cursory survey of the adjacent forests. It is realized, however, that their proximity to the bog, the relative amount of pollen produced, and the direction of prevailing winds during anthesis, as well as other factors influence their relative representation in the pollen-bearing sediments.

Climatic Considerations.

In recent papers on pollen analysis the writer has emphasized the possibility that other than climatic factors have been largely responsible for postglacial forest succession in the Pacific Northwest. Notwithstanding, he has made tentative climatic interpretations pending the analysis of a greater number of bogs and a more critical correlation of their pollen profiles. Certain conclusions from earlier studies may have to be revised in lieu of further investigations. The postglacial successional trend of a species in different climatic provinces and climax formations may serve to clarify its climatic relationships. It seems probable that there have been climatic trends during the estimated 25,000 years or so since the recession of the last ice-sheet, but the forest succession as interpreted from pollen analysis does not clearly depict these trends. In the Lake Region and the glaciated portion of eastern United States, pollen analyses reflect a rather definite climatic trend in the gradual disappearance of boreal tree pollen in the upper strata of peat deposits. The initial postglacial boreal forests migrated beyond range of pollen-dispersal to the bogs, and were replaced with those that thrive in more moderate climate. This is not true in the Pacific Northwest where the earliest recorded spe-

cies may still exist extensively in the same climatic province with both climax and subclimax species represented in recently deposited peat. In some bogs a species records the highest proportion of pollen in both the lowest and highest levels, while others may show little fluctuation throughout the profile. The proximity of the Pacific Ocean undoubtedly has been a moderating influence in maintaining a more static postglacial climate than that of the Lake Region.

Many conifers in the Pacific Northwest seem to be better indicators of humidity than temperature, except subalpine species that do not exist in extensive stands. Temperature and moisture are probably the chief opposing factors of the environment, and their interplay and physiological compromise modify the influence of each other, while other factors in turn alter them. The relative tolerance for shade of the various conifers is one of the more important factors in controlling their successional relationships. This is indicated by the persistence of subclimax species where the trend of climax forest development is retarded, disrupted, or prevented from attaining its end. Fire, lumbering, and fungal and insect diseases are the chief agencies in effecting this course of events. The extensive geographic and climatic ranges of the species concerned and the overlapping of their ranges constitute some of the principal features that cause uncertainty in the interpretation of climatic trends from pollen analysis. The presence of a species in several areas may reflect different climates depending upon the ecological relationships of the species with which it is associated. On the other hand, a species may react differently in areas of similar climate if associated with different species, or edaphic and topographic conditions. The longevity and age of seed production would be important characteristics in regions of unstable environment. This would be especially true near the margin of a continental ice-sheet, where continual oscillation of the ice-front would create both changing climatic and edaphic conditions. Lodgepole pine would be at an advantage here, because of its early age of seed-bearing and its less exacting soil requirements (Larsen, 1929). The pioneer, postglacial invasion of lodgepole pine in the Pacific Northwest is perhaps largely due to unstable edaphic conditions, and its ability to migrate and re-establish itself before an oscillating ice-front. Its invasion of bogs in their climax stage is further evidence of its ability to thrive under edaphic conditions unfavorable for other species (Hansen, 1940a). After such conditions have been ameliorated by lodgepole pine forests, other species invade such areas and gradually replace the former because of its greater intolerance for shade. An increase in the percentage of pollen of a species in one bog may reflect a different trend of climatic fluctuation than its increase in another. This would depend upon the existent climate, its ecological relationship with the species or group of species it is replacing, and the climatic trend. Briefly, the successional status of a species is an expression of its ecological relationship with the others present, the existing environment, their relative demands upon the environment, and their physiological compromise. Climate may remain at an equilibrium, and forest succession may still proceed and reach a climax controlled largely by the biotic, edaphic, and physiographic factors.

Lodgepole pine is perhaps the poorest climatic indicator of the conifers recorded in the bog of this study. Its early invasion was probably due to its proglacial existence near the ice-margin, its non-selective soil requirements, and its early age of seed production. The recent presence of the ice in itself suggests a cool initial climate, but as far as precipitation is concerned, it is possible that a subhumid condition prevailed because of air currents moving

off the ice. The existence of lodgepole pine in the wet climate of the Pacific Coast may indicate its tolerance rather than its demand for a moist habitat, for it seems to thrive only in sandy and well-drained soils. Neither is its occurrence on climax bogs indicative of a hydrophilic nature, because a bog may be physiologically dry so far as available water is concerned. The gradual and almost constant decrease in lodgepole pine throughout the profile is probably due to its inability to compete with more tolerant and longer lived species. It is the least permanent in the northern Rocky Mountain region (Larsen, 1929), and this is also true in the Pacific Northwest. The profile of western white pine does not show sufficient fluctuation throughout to warrant any climatic interpretation. That of western yellow pine is the most significant and shows the most definite trend. Its sharp increase from 4 per cent at 3 meters to 53 per cent at 1 meter suggests a drying of the climate. Yellow pine is more tolerant than lodgepole and less so than white pine, and thrives with less moisture than the latter. An increase in moisture would probably result in an increase in white pine because of its greater tolerance. The decrease of yellow pine from 1 meter to the surface may be the result of climatic change, normal forest succession under static climate, or interruption of succession by fire or disease. In the latter case, the destruction of yellow pine in adjacent areas would increase the proportions of other conifers, but not necessarily their actual abundance. Yellow pine is the most important commercial tree in this region, and its removal by lumbering in recent time may be responsible for its continued decrease at the surface. The analyses of two other bogs in the yellow pine forest, but nearer the timberless zone, indicates a gradual increase to a maximum which is maintained to the present (Hansen, 1939b, 1939c).

Douglas fir pollen is absent in the lower levels, but is present at 2.75 meters and reaches its highest proportion at the top. Its sharp decrease from the volcanic ash layer to 1.25 meters is difficult to explain. It might well represent an interruption of normal forest succession, because Douglas fir is more tolerant than either lodgepole or yellow pine and would normally replace them, other factors remaining at an equilibrium. The question always arises as to what extent the sources of error inherent in pollen statistics are involved in these minor fluctuations.

TABLE 1. PERCENTAGES OF FOSSIL POLLEN

Depth in meters	3.25	3.0	2.75	2.5	2.25	2.0	1.75	1.5	1.25	1.0	.75	0.5	0.25	0.0
Pinus contorta	68	65	60	51	47	42	27	34	23	18	22	18	16	20
P. monticola	21	10	21	21	24	26	28	26	18	16	19	16	14	18
P. ponderosa		4	2	6	16	17	20	23	45	53	40	45	36	28
Pseudotsuga mucronata			1	3	4	7	20	10	7	10	12	16	18	22
Tsuga heterophylla	1					1			1		1		1	1
Picea engelmanni		1		1			1	1	1		1	1	1	2
Abies grandis		1			2	4	2	2	1		1	1	1	1
A. lasiocarpa				1					2		1	1		1
Larix occidentalis	3	2	2	2	1	1		2				1	10	7
Gramineae	6	15	13	13	4	2	1	2	1	3	2	1	3	
Compositae		1	1	2	1									
Chenopod-Amaranth	1	1			1		1		1		1			
*Alnus**	12	9	1	9	8		1	3	5	3	11	8	4	2
*Acer**	1	6	14	22	27	11		1	2	3	1	2	4	3
*Betula**	1	2	3	15	7	2	4		3	2	8	4		1
*Salix**	4	2	1	1	3					5	2	3	3	
*Cyperaceae**	3	3	4	4	3	3	3	2	7	1	12	43	98	52
*Typha latifolia**	1	3	3	1	2	11	8	4	2	5	4	1	6	2
*Nymphaea polysepala**					3					1	1	4		

*Number, and not computed in the percentages.

Western larch is the most common of the other conifers, and its increase to appreciable proportions in the upper two levels may be the result of fire or fire or insects. Larch is resistant to fire because of its thick bark (Larsen, 1929) and the least subject to insects attack of the conifers (Keene, 1939). After several fires in close succession, it rapidly increases, but is gradually replaced because of its intolerance. It seems doubtful whether larch is a critical climatic indicator. The almost entire absence of western hemlock throughout the profile is similar to its status in other bogs located with the timbered Arid Transition zone (Hansen, 1939b, 1939c). Apparently this region was not sufficiently humid during the postglacial period for hemlock to thrive, as it needs considerable shade, moisture, and humus for germination and growth of its seedlings.

SUMMARY

Pollen analysis of a post-Wisconsin peat deposit in northern Washington, located within the Canadian Life zone, indicates that the pioneer forests to invade adjacent areas consisted chiefly of lodgepole and white pine, with some grass.

Lodgepole pine was gradually replaced to a large extent by yellow pine and Douglas fir, with a preponderance of yellow pine. White pine remained static and apparently was never predominant.

A decrease in yellow pine in the upper levels is difficult to attribute to climatic change. It may be due to normal forest succession or an interruption of succession by fire or disease. The continued decrease at the top may reflect the result of the recent lumbering operations in this region. The concurrent increase of Douglas fir in the higher levels, may suggest normal succession under static climatic conditions.

Climatically, the forest succession suggests a gradual drying and perhaps some warming to a maximum when yellow pine attained its maximum, from which time the climate has remained about the same.

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Pleistocene Deformation in the Olympic Coastal Region, Washington

By SHELDON L. GLOVER*

Recent work for the Washington State Division of Geology on the stratigraphy of the Pacific Coast border of the Olympic Peninsula has shown the existence in some places there, of marked Pleistocene deformation. Evidence of such movement is unusual enough to be of interest wherever it occurs, and this is particularly true of western Washington where, heretofore, folding in Pleistocene strata has not been recognized.

Many writers have touched on Pleistocene events in the western part of this state, but the most detailed accounts are those by Willis[1] and Bretz[2]. Both investigators recognized that the land had been uplifted and depressed during the Glacial epochs, but concluded that folding was not involved in such movements. This may be entirely correct for the areas that received almost exclusive attention; i. e., the region adjacent to Puget Sound. Excellent exposures there that permit detailed examinations to be made in countless places demonstrate the horizontal attitude of the sediments. It must be remembered, however, that these exposures are predominantly of Vashon beds, and that the scarcity of Admiralty sediments (using Willis' delineation of such material) permits only generalizations to be made on the structure of the earlier deposits.

On the coastal area of the Olympic Peninsula, Pleistocene sediments form the surficial deposits and, in some places, erosion has provided excellent exposures. These may be studied in the bluffs fronting the ocean and in banks of many of the larger streams. It is evident that two series are present. One, much older than the other and presumed to be early Pleistocene in age, is here termed the Taholah formation; the younger series, probably of late Pleistocene age, is here termed the Queets beds. From the available evidence, they are thought to correlate with the sediments of Admiralty and Vashon age, respectively, of the Puget Sound region.

The Queets beds, as might be expected, if they are the correlatives of the Vashon sediments, have undergone no known diastrophic disturbance. In some places they have been involved in large-scale block landslides and so give the appearance of local deformation. Also, minute but well-marked faulting and minor warping occur, but such effects have resulted from local adjustments to gravitational sags.

The Taholah formation, too, is mostly horizontal, and throughout great areas shows little, if any, inclination other than that due to primary dip and cross bedding, such as characterize sediments deposited from over-burdened streams. However, there are places where these beds are deformed, and further investigation will doubtless show more evidence of such movement in widely separated regions. One outstanding example is in the Taholah-Moclips vicinity where a sedimentation phase of the Taholah formation occurs that is quite distinct from the usual type. In this particular area the sands, gravels, and occasional clays were deposited in a subsiding basin, presumably an estuary, and so accumulated to a thickness far greater than is known elsewhere on the coast. Detailed sections of as much as 475 feet have been measured, and the persistent structural attitude of scattered exposures indicates that the total thickness of the formation is in excess of 1,500 feet. Individual beds of relatively well-assorted sand many be as much as 75 feet thick, though moderate thicknesses are the rule. The materials are unconsolidated, as contrasted to the Tertiary strata of

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the vicinity, but the sands and gravels are weakly to firmly cemented by iron oxide so that exposures offer sufficient resistance to erosion to attain vertical faces above the cutting agent.

The strata are well exposed in places along the Moclips River and there have been folded into a broad asymmetrical anticline that trends northwesterly. Dips on the west flank are as steep as 42 degrees; on the east flank they are in the amount of 10 to 15 degrees. It is of interest to note that the presence of this structure was doubtless the reason for an oil exploration program conducted by the Standard Oil Company of California in about 1920. Two test wells were drilled in this vicinity and reached a reported depth of approximately 4,000 feet.

Another series of exposures which provides good evidence of Taholah deformation and shows the relationship of that formation to the older Quinault rock and the younger Queets beds is in the vicinity of Wreck Creek. South of the creek a mile or so are occasional poor exposures that indicate the beds there are virtually horizontal. At 2,000 feet south of the creek they have a small but definite easterly dip; this is shown in an old railroad cut that exposes 15 feet of Taholah sand, underlain unconformably by some 30 feet of Quinault sandstone and overlain by 15 feet of horizontal Queets gravels. Exposures north from there to Wreck Creek are fairly continuous and show the strata striking nearly east and steepening to a 45 degree north dip in the bank of the creek. This general trend continues to the axis of the fold, approximately 2,000 feet north of the creek; beyond that the easterly trend is maintained, but the dip is southerly to as much as 22 degrees in the exposure farthest north. The structure here is that of an asymmetrical syncline, plunging easterly at an angle of six degrees or so, and conforms with an axis of anticlinal folding that trends through Point Grenville.

A third, and more spectacular, series of exposures is in the south bank of the Quinault River, southeast of the Indian village of Taholah. Here erosion has cut through the Queets beds in many places, exposing well-stratified thick beds of iron-stained sand and gravel for nearly two miles along the river. One-half mile from the village the series crops out in a high bluff where a stratigraphic thickness of 230 feet of sediments strike N. 5° E., and dip 30° S. E. For 4,000 feet upstream the exposures are poor, but such data as are available indicate a remarkable persistence in attitude to as far as the sharp bend in the river near the center of sec. 6, T. 21 N., R. 12 W. The northerly course of the river in this section appears to have structural control, and massive Taholah gravel is exposed in the left bank. Only Quinault sediments are exposed for the next thousand feet or so upstream from this stretch, and though the juncture of the two formations is concealed, the anomalous relations indicate that the two series are in fault contact.

The small area of older rocks is characterized by extensive landslides, and nothing definite is known of the structure. Profound disturbance, however, is indicated by the sheared and broken condition of shale masses in the nearly black mud that has resulted from their disintegration, and by flexures from 0° to 45° in non-disintegrated masses not over 30 feet across that may or may not be in place.

The Taholah formation is again exposed for 3,000 feet upstream from the east boundary of the area where the older rocks crop out. The contact here is remarkably well exposed and shows that the Quinault formation has been faulted up through the thick early Pleistocene cover. Erosion has stripped the sheared and easily weathered shales from the fault surface and left the Taholah series standing nearly vertically, high above the adjacent shales. This surface trends N. 40° W. and dips 78°

S. W. There are no indications of parallel breaks or of the development of a pronounced fault zone, but patches of mashed shales, a few inches thick, adhere to the fault plane.

The younger sediments, chiefly sands, on the east side of the fault are only weakly cemented by iron oxide, yet they form a cliff nearly 150 feet high. These strata strike N. 60° W. and dip 70° N. E. at the fault; this attitude gradually changes in 100 feet or so to a strike of N. 40° W., 40° N. E., and at the east end of exposures, 3,000 feet beyond the fault, the dip has decreased to 6° and the strike is N. 15° W., conforming rather closely to the regional trend in this general vicinity. Horizontal Queets beds, undisturbed by the movements that affected the earlier formations, overlie this whole area.

The deformation along the Moclips and Quinault rivers was described by Lupton[3] in 1914, and two years later Weaver[4] mentioned the conditions prevailing on the Quinault River. However, both investigators believed the folded early Pleistocene beds to belong to the Quinault formation and variously estimated their age, in consequence, as Miocene to Pliocene. Only the flat-lying surficial gravels (the Queets beds) were accounted as representing Pleistocene sedimentation. Presumably, Lupton thought the up-faulted block of Quinault formation to belong to the "supposed Cretaceous" series of Arnold[5]; while Weaver definitely places it in that category when he describes it as belonging to the "Hoh formation".

The attitude of the exposures on the Moclips and Quinault rivers indicates an axis of folding roughly parallel to the coast as the major structural control of the Taholah formation in this immediate area. Such deformation is in accord with the dominant folding that affects the older rocks and extends far to the north in the region adjacent to the coast. A transverse fold, the Wreck Creek syncline, has been impressed on the regional structure, and it is reasonable to assume that others exist. If exposures were available, it would probably be found that relics of the folding that produced the Grenville anticline and bordering Quinault syncline also affected the Taholah sediments. This deformation, therefore, appears to be due to recurrent movements along certain lines of weakness that persisted through the early Pleistocene but which have been inoperative since that time.

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Abstract

Addition of Feldspar to the Kettle Falls Quartzites

By CHARLES D. CAMPBELL
State College of Washington

The quartzite formation at Kettle Falls is traversed by a pegmatite sill, but has received little or no feldspar. A few miles to the west, in Hoodoo Canyon, some ten per cent of it has been replaced by rounded orthoclase crystals. These lie along and parallel to small healed fissures cutting across the schistosity of the quartzite at right angles. Still further to the west, all quartzites, whether correlatives of the Kettle Falls quartzite or not, contain substantial proportions of orthoclase and micas, reflecting their nearness to the underlying Colville batholith.

Abstract

A Phosphate Pegmatite From Eastern Latah County, Idaho

By VERNON E. SCHEID and R. M. ALLEN

A pegmatite dike, containing an assemblage of relatively rare phosphate minerals, has been found in the Mica Mountain region of eastern Latah County, Idaho. The pegmatite occurs in rocks of the pre-Cambrian Belt series that were metamorphosed to schists and gneisses by the intrusion in late Cretaceous time of the granitic Idaho batholith.

Intrusion of the pegmatitic material into the schistose country rock involved both injection and replacement. The pegmatite, which was originally typically graphic granite, has been subjected to periods of intense silicification, albitization, tourmalinization, and finally phosphate mineralization. Until the introduction of the phosphate minerals, the pegmatite was identical with many others in the region.

The minerals of the magmatic stage are quartz, microline, and muscovite. Through the action of ascending hydrothermal solutions, they were replaced in successive stages by: (1) quartz, which was, however, active throughout the entire intrusive period, (2) albite, (3) muscovite, (4) tourmaline, and lastly the phosphate minerals, (5) strengite, (6) vivianite, (7) triphylite-lithiophilite, and (8) salmonsite(?).

Abstract

Correlation of Some "Latah" Beds of Nezperce County, Idaho

By R. H. UPSON
University of Idaho, Moscow, Idaho

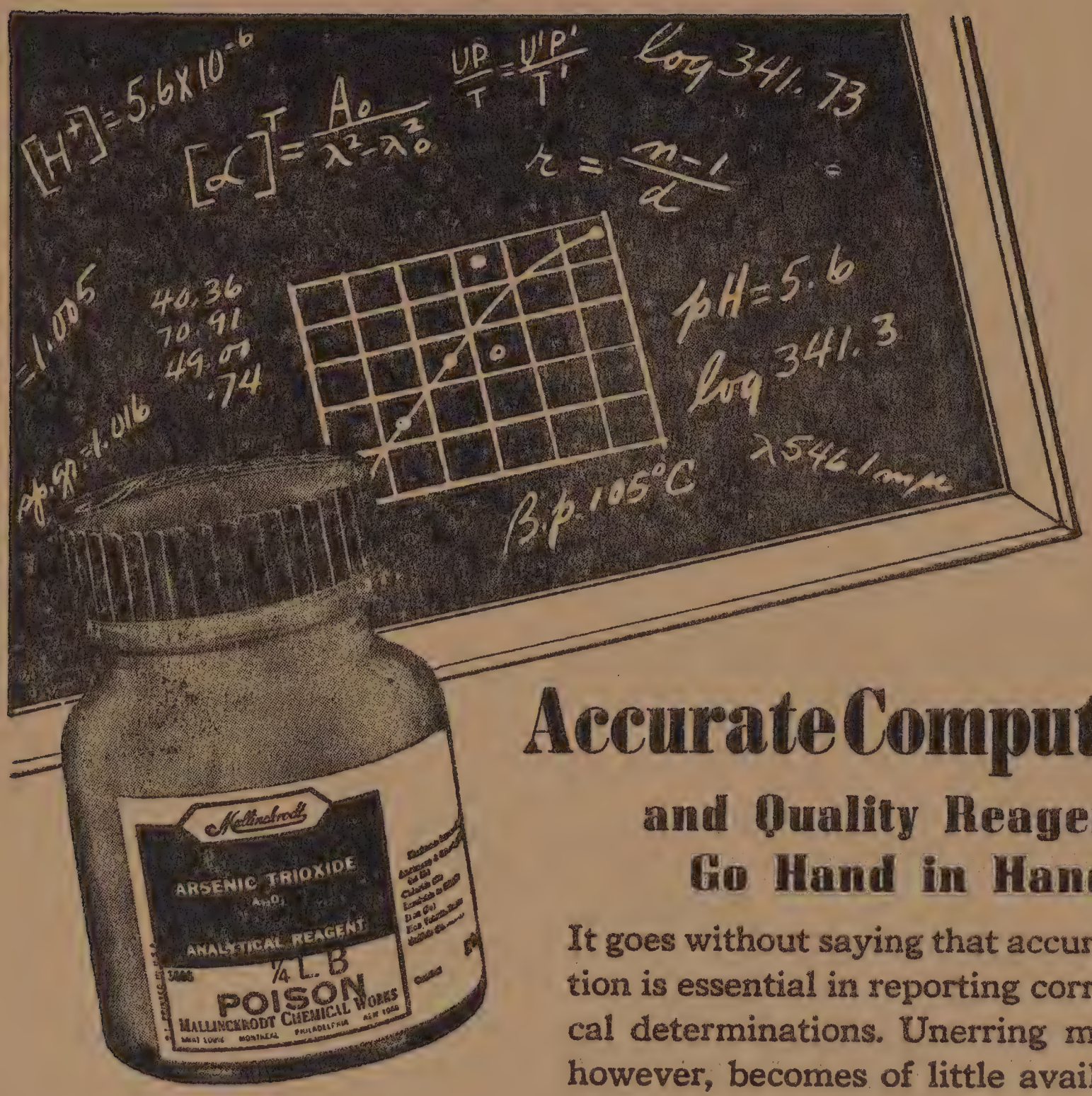
A fossil flora collected from exposures of "Latah" beds near Juliaetta, Arrow Junction, and Fir Bluff Station, Nezperce County, Idaho, is similar to that found in type Latah beds near Spokane and Republic, Washington, thus strengthening earlier correlations. Most of the exposures of the sediments, intercalated with the Columbia basalts, are in place and not in landsilde blocks. The occurrence of crossbedded sandstones interbedded with the fossiliferous clay layers indicates that the sediments are not wholly lacustrine, but in part fluviatile in origin.

Abstract

Pleistocene and Recent Normal Faulting in Southern Colorado

By R. H. UPSON
University of Idaho, Moscow, Idaho

Several small fault scarps, or scarplets, in alluvium have been discovered at and more or less parallel to the west base of the Sangre de Cristo Range in the Southern Rocky Mountains of Colorado and New Mexico. The presence of the scarps not only demonstrates the existence of recent fault movements in the region, but also supports previous postulates of Pleistocene movement. Thus, the region appears to be related tectonically to the Great Basin and other areas of Pleistocene and Recent normal faulting.



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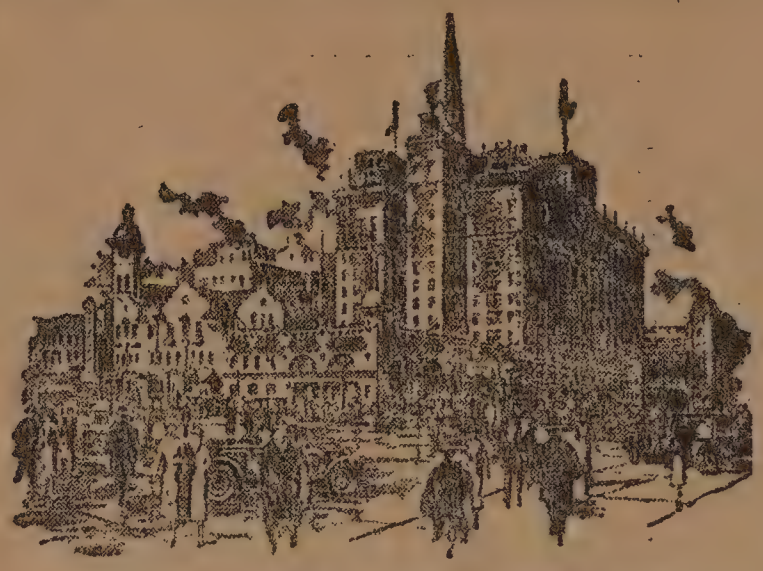

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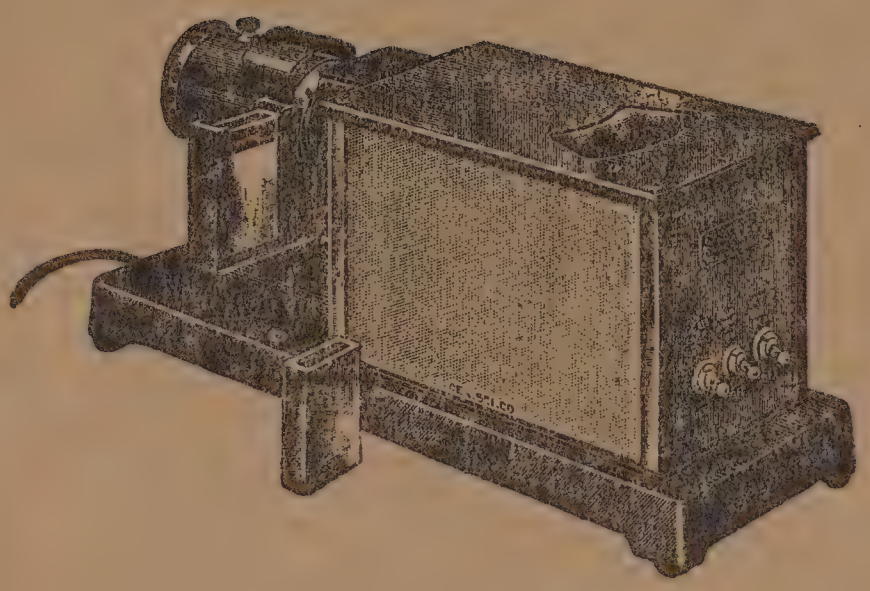

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Annual Meeting N. W. S. A.

The Seventeenth Annual Meeting of the Northwest Scientific Association will be held Friday and Saturday, December 27 and 28, at the Davenport Hotel, Spokane, Washington.

Key speaker for the 1940 session will be Dr. John B. Appleton, Assistant Director of the Northwest Regional Planning Council, Portland, Oregon. At the first general session Friday morning he will address the Association members on "The Role of Research in Regional Development."

Dr. Appleton will also speak at the annual banquet Friday evening, taking as his subject "Putting Research to Work."

Friday noon the Association will hold its joint meeting with the Associated Engineers at Spokane. Dean A. W. Fahrenwald of the University of Idaho School of Mines will address this meeting on "Certain Aspects of Modern Metallurgy."

Aside from the general session speakers, each of the eight regular sections of the Association has a full program planned, and one of the largest registrations in the history of the organization is anticipated.

WILLIS B. MERRIAM,

Secretary.

Authors of papers to be presented at the meeting of the Northwest Scientific Association at the Davenport Hotel, December 27th and 28th, are requested to furnish three copies of abstracts of their contributions to the Secretary of the Association. Two copies will be for the use of the press and one copy will be retained by the Editor of NORTHWEST SCIENCE. In so far as is possible it is desired to publish in NORTHWEST SCIENCE at least an abstract of all papers presented at the meeting. Abstracts may vary in length from 100 to 500 words. Members who desire that their papers appear in NORTHWEST SCIENCE are earnestly requested to deliver the same to either the Secretary or the Editor of NORTHWEST SCIENCE during the meeting of the Association.

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Liesegang Rings IV

By ANDREW VAN HOOK

**Department of Chemistry and Chemical Engineering,
University of Idaho, Moscow**

Ever since the attention of the scientific world was focused on the phenomenon of rhythmic precipitation by Liesegang in 1896, there have been numerous comparisons drawn between this phenomenon and many natural processes. Such matters as the structure of agates and flints, the rhythmic swarming of various bacilli, the banded structure of various concretions, the markings on wasps, tree rings, and many other geological and biological occurrences and processes have been mentioned in this respect[5-2]. Some writers even offer the Liesegang phenomenon as an explanation of many of these processes; and while there has been no immediate objection raised in the case of agates, there might be considerable skepticism displayed when the annular markings of trees are mentioned in this way.

In fact these very extremes have been examined critically by Jablczynski[4]; and he concludes that the former is a true Liesegang phenomenon, but the latter is not. The criteria employed were the quantitative requirements found to hold very exactly for synthetic Liesegang rings. These specifications are:

$$\frac{x}{\sqrt{t}} = k. \text{ and } \frac{Xn}{Xn\text{-}1} = \frac{\Delta Xn}{\Delta Xn\text{-}1} = A;$$

where x and t are the distance and time of formation respectively of the n-th rings or band. k and A are constants; known as the Morse and Pierce, and Jablczynski ratios respectively.

These relations are well known, and their accuracy fully warrants accepting them as criteria of the Liesegang phenomenon. Other than the instance cited above they have not been applied extensively to geological and biological cases. Perhaps the reason is that in most of these examples the bands are insufficient in numbers and definition, and the formulae are derived and confirmed for a large number of bands. To simulate the more natural condition, various Liesegang ring experiments were performed in which limited quantities of both inner and outer reactants were used; thus producing a limited number of bands. It is difficult to produce fewer than four or five distinct, measurable bands. In the cases of only a few bands there were definite deviations from the Jablczynski constant; the values diminishing with the larger bnad numbers. The change however is regular and neither erratic nor large.

To apply these quantitative ideas to natural objects, one may select the apparently infrequent sample with a large number of rings and expect a constancy of the ratios of successive positions of the bands; and, for the more common example of only a few bands, one would expect a regular and not too large change in these values. A few examples in the former class have been found in the literature, and in specimens available. Table I records the values of the Jablczynski ratio for these specimens and illustrations. Data on synthetic Liesegang rings of silver chromate and lead iodide are included for comparison. While a good many natural objects examined exhibit a multitude of rings, it is immediately apparent that only a few of these bands occur with any regularity. It is only these sections which are of interest.

There can be no question concerning the constancy of the values of the first three rows in Table I, and likewise concerning the variance of values in the last two. There is also an appreciable variation over the whole range in the case of the bacillus vulgare. On this same photograph in a southerly direction the measurements are about the same as presented. In other directions

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however the five or six successive constants disappear and hence these best values presented may be ruled out as fortuitous and exceptional.

There is available much more data on systems with a smaller number of rings. Typical ratios of successive distances are given in Table II. These illustrations could be increased abundantly. but the results tabulated are typical of the measurements on hand and in the literature. The irregularily within a section selected as being most similar to the synthetic Liesegang phenomenon is sufficient to discourage any suggestion of both processes being the same. However it is possible to obtain results in synthetic cases very similar to the natural behavior, if the composition of the inoculating reactant is altered during the experiment.

In summary it may be stated that the natural cases of banded structures, other than agates and other geological illustrations, do not fit the quantitative requirements of the Liesegang ring phenomenon. While this disagreement does not eliminate the possibility that natural structures are the result of interrupted and occasional diffusional processes, it hardly justifies designating the result as a Liesegang phenomenon; for the process in such a case is merely the growth of the object. In gall stones it is undoubtedly a variable pathological environment which gives rise to the banded structure. Diffusion may be a secondary factor in this and similar cases, and the fact that Weiser[9] has produced gall stones artificially in this way suggests this situation. Whether the actual deposition is by apposition or **in situ** can not be decided by the data given. If the instigating disturbance is constant in quality the former mechanism is indicated.

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TABLE I
Values of A

Ring No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ag_2CrO_4—capillary	—,	1.19,	1.20,	1.19,	1.19,	1.20,	1.20,	1.20,	1.19,	1.20,	1.20,	1.20,	etc.	
PbI_2—petri dish	—,	1.07,	1.06,	1.06,	1.07,	1.06,	1.06,	1.06,	1.06,	1.06,	1.06,	1.06,	etc.	
Agate, unknown source	—,	1.11,	1.14,	1.12,	1.13,	1.12,	1.15,	1.12,	1.12,	1.10,	1.11,	1.11,	etc.	
Bacillus Vulgare swarm, Knoll[5], Fig. 3 (west)	—,	1.43,	1.30,	1.19,	1.11,	1.14,	1.09,	1.12,	1.08,	1.06,	1.07,	1.06		
Gastrolith[7], Fig. 44 (north)	—,	1.23,	1.19,	1.95,	1.28,	1.26,	1.14,	1.44,	1.52					
Gall stone (F. N. I)	—,	1.18,	1.31,	1.60,	1.43,	1.32,	1.30,	1.24,	1.31,	1.11,	1.19			

(FN. I)
Dr. F. W. Ash of St. Joseph's Hospital, Paterson, N. J.; Dr. D. Loehr of Moscow, Idaho; and other physicians have presented me with a great number and variety of concretions. This one stone, of unspecified history, was the only one, of hundreds, which exhibited a large number of regular bands.

TABLE II
Values of A

Ring No.	1	2	3	4	5	6	7	8
Ag_2CrO_4, petri dish	—	1.71	1.57	1.53	1.49	1.44	—	—
Ag_2CrO_4, capillary	—	1.41	1.36	1.21	1.14	—	—	—
PbI_2, capillary	—	1.17	1.12	1.11	1.09	1.07	—	—
PbI_2, Petri dish	—	1.24	1.20	1.21	—	—		
Gall stone. unknown history	—	1.27	1.61	1.64	1.43	1.42	—	—
Gall stone, Fig. I[8]	—	1.69	1.29	—	—			
Gall stone, Synthetic, Fig. V[9]	—	2.04	1.43	1.22	1.11	1.10	1.10	—
Natural, Fig. III[9]	—	2.15	1.38	1.43	—	—	—	
Bacillus Vulgare swarm Knoll[5], Fig. VII	—	2.08	1.69	1.40	1.25	1.17	1.19	—
Fungus[3], Fig. 3	—	.82	1.03	1.30	—	—	—	
Tree conk	—	1.07	1.19	1.08	1.34	1.26	—	—
Beet root markings[1] Case D	—	.85	1.27	1.34	1.51	—	—	—

Conservation Problems of the Inland Empire

By MRS. E. L. DENNIS
Spokane, Washington

In presenting these conservation problems of the Inland Empire I come to this meeting as a member of the general public, not as a true scientist. I am a nature hobby enthusiast who has enjoyed, taught and studied nature for many years because I want to, and because I think people of the Inland Empire need to do so. For many years I have enjoyed teaching children's groups and helping the leaders of children's outdoor groups to enjoy nature lore.

A keen interest in conservation has naturally become a part of these studies and activities and certain problems have been faced.

Will you turn with me the pages of my conservation notebook, a collection of news clippings covering these problems and carrying them over a period of several years; mainly from 1936 to the present date?

I feel strongly that if the present generation of people living in the Inland Empire do not face these conservation problems with more intelligence and courage than is now being used we will be guilty of stealing from the next generation and those to follow it. Less than two generations of white people have lived their lives in the Inland Empire. We can rightfully suppose that many more will live here. We two have used more than our share of everything. We have wasted the plenty which we found here; the plenty that was intended for all generations to come.

I need not talk to you of soil and forest problems. They have been recognized and are being studied and corrected as you know. There are other problems.

One of enormous importance to future generations is the waste of bird life. Many ornithologists think that if birds were to disappear from the earth mankind would disappear also in less than a year. After studying the economic importance of birds for several years and watching what birds eat, I doubt if the last few months of that year would be worth living.

From the Pasco region have come startling reports of grasshopper and cricket invasions each year since I started this notebook. By last summer they had spread to many other towns—Grand Coulee, Davenport, Sprague, Colfax, Creston, B. C., my own vacant lot and many communities in Colorado, Idaho, Oregon and Montana. Such headlines as these cover the pages devoted to insects—"Hopper Cloud Falls Like Rain," "Munching Horde Ruins Ranchers," "Cricket Menace Becomes Grave," "Hopper Horde Imperils Crops."

Turn to the pages of rodents in the Inland Empire. I remember reading articles telling how field mice have ruined parts of the Ohio Valley and sections in Pennsylvania and New England. Here are stories about poisoning ground squirrels and gophers, farmers warring on rats in the Fairfield area, apple growers battling mice near Yakima, jack rabbit and mice menaces to farmers' crops and rabbit plagues in the Davenport area. There is a statement of T. B. Murray of the Biological Survey saying that injury by rodents may amount to 99.4 per cent on deteriorated range lands.

I can't help remembering the fat ground squirrels that used to scamper over the ranges of our old cattle ranch and the clean little circles that began at the front door of each squirrel and spread until there was not much left for the cattle and us, in early spring.

Searching through the clippings for answers to these situations there are headlines about great amounts of money being spent by state and federal

governments. I read of poison bait, fighting crickets by fire and by hand, of traps and rodent or vermin control contests. I find that hawks, owls and gulls ate steadily against the cricket invasion at Pasco. The United States Biological Survey reports that most of our hawks and owls are definitely beneficial in the Inland Empire because they feed largely on grasshoppers, crickets and rodents. A report from the Yakima valley and a study made recently at the University of Idaho uphold that statement, but I find no clippings about hawks and owls being invited by man to help him. I read of no one bringing over a few extra gulls to help at Pasco. Birds are even being discouraged in many ways. Many vermin contests list hawks and owls as vermin and offer bounties for them. Some do designate the few destructive species but the hunters frankly admit they can't tell one hawk from another and some were seen late in 1939 shooting at beneficial owls. Last year one was seen trying to kill a sparrow hawk which feeds almost entirely on grasshoppers and small rodents. One report of a contest gives credit to one hunter for the death of 74 hawks and to another for the death of 98 owls. Any person who knows the birds of the Inland Empire is sure those men did not kill that many destructive birds. They just could not find that many.

I have often hiked all day and not seen one hawk, and most of those seen are beneficial species.

Scientific people of the region should put out such a campaign of education on the value of hawks that no one would dare kill a good one. The coming generations will all need hawks and owls and gulls. We need to know how to encourage and protect them and let them do this insect control that is costing the government $2,000,000 in money each year and several times as much in produce.

Orchards and city parks are being eaten up by insects that song birds like for food and many of these pests have spread to native plants and are ruining some of our most beautiful natural parks. All over the area oyster shell scale is killing willows, dogwood and many other shrubs and trees. Yet almost all parks do the very things that drive birds away. They spray, cut out all brush heaps and hedges that give birds nesting sites and safety, and allow water supplies to dry up.

Our forests are being damaged each year to the tune of many thousands of dollars by insects such as bark and engraver beetles. Woodpeckers used to keep these tree enemies under control but woodpeckers are still being used as targets by youngsters who do not understand.

Wild flowers make one of the best tourist attractions known and give the inspiration and relaxation of colorful beauty to citizens of the Inland Empire. Thousands of people go to Rainier and California and other famous flower gardens of the world and out to drive in the spring. But wild flowers are not sure to be here in the future years as things are today. Even though we have a state law protecting them along the main highways, people pick armloads at the very roadsides. We saw them doing it last spring. We saw them spring before last and will likely see them doing it again next spring.

The country is full of people who remember lovely flower displays from pioneer days in the Inland Empire but who find only an old forest burn or an over-pastured hillside when they go to see them again today. Many of our most beautiful wild flowers such as the Lady Slipper or Cypripedium and the Indian Pipe were quite well known to early flower lovers but will never be seen by most people now living. What will be left for your children and their children and grandchildren?

This wild flower situation can be corrected. It is caused by several problems that science can solve.

First--many people have had no op-

portunity to know one flower from another nor to become acquainted with the conservation facts of the area. What natural science is taught is often given by teachers trained in the east or in California. We need to establish a training center for science teachers for the Inland Empire. The Inland Empire is individual in her flora and bird life. Her problems are her own and her own people can solve her own future best. They understand her.

Ever since I started my hobby I have been looking for a good book that would help we know "What flower is this?" I think I have seen every book in publication but I am still looking. No book is complete and they all differ in both scientific and common names. There is no common language of flowers in the great basin of the northwest. There is no book for the lay person without knowledge of scientific terms.

There needs to be a publication which will keep nature lovers up-to-date on the scarcity or abundance of certain species, the reasons for protective rules and laws and there need be reserves set aside to keep forever as breeding grounds of plants and birds.

Many scientific studies will be needed in work on each problem presented to you here today and surely it is fitting that science of today works for the people of tomorrow. I sincerely hope that the members of the Northwest Scientific Association will choose some of these problems for solution in the near future.

Geology, Its Place in Science and the School Curriculum*

By J. D. FORRESTER
Department of Geology, University of Idaho

This title of the subject upon which I have elected to speak opens up a wide field of approach. Geology may be defined as the science which treats with the history of the earth and its inhabitants, as recorded in the earth's crust. More specifically, it is concerned with the composition, character, and architecture of the earth and with the natural agencies and processes which continually have been and are now altering it. We study those substances, both within and on the earth, that compose its body. We study the character that the earth has in respect to other heavenly bodies—how it reacts to outside influences and how it behaves inwardly and on its surface. The term architecture, as here used, pertains to the rock framework of the earth and to the natural forces which are constantly acting upon this structure.

The natural agencies that influence and alter the earth's crust are wind, water, and ice. For instance, we have all seen streams running over the surface and carrying tremendous loads of rock and soil. They are, as you can see, affecting the rocks of the crust when they transport this material from one place to another. Geologic processes refer to a multitude of features. I might cite the action of volcanoes as one example; another is the occurrence and propagation of earthquakes. Indeed, there are many other natural geologic phenomena.

Geology is a big subject. As we strive for the full answer to questions about the earth, we enlist and use all of the other natural sciences. Although geology is not an exact science in the strict sense of the word, it has been called rightfully the broadest of all natural sciences in that it enlists and chooses what it will from the collaboratory fields of biology, zoology, chemistry, physics, mechanics, and so on. Geology is a fascinating subject since it includes not only a study of the physical conditions and history of the earth from the time of its beginning, but it deals with the orderly appearance and development of all life on the earth as well. The procedure we follow in an attempt to answer these questions which arise, is to observe conditions and happenings as they occur day by day on the earth's crust. We then use the observations as a key with which to unlock the secrets of the past that are recorded and waiting for translation in the great volume of the rocks. For example, studies of the present volcanic activity on Hawaii give us a clue or key as to what occurred over much of Idaho and the Pacific Northwest thousands and thousands of years ago, as is now evidenced in the rocks of this region.

There are two fundamental reasons why we make these studies of the earth. They are, namely, (1) for the economic advantages we may gain through having a knowledge of geologic principles. A geologist is called upon to not only classify minerals and rocks, but to locate valuable mineral deposits and to direct their exploration. He gives counsel regarding dam sites, tunnels, foundations, irrigation systems, the control of floods, and of other engineering projects; (2) for purposes of increasing our general knowledge of the earth upon which we walk and to become familiar with the natural wonders we see on every hand. By such familiarity with the grandeur of nature, we must necessarily become better people with whom to live.

It is my purpose to consider the science of geology from its aspect as a true economic science and also quite fully from the cultural and popular standpoint. The growth of science to its

*A talk delivered to the Geology-Geography Section of the Inland Empire Teachers' Association, April, 1940.

present substantial proportions is largely the result of the intellectual curiosity of the human mind, but the practical problems and commercial aspects of geologic principles have tremendously stimulated the growth of the science.

A geologist, highly trained in the profession of geology, is a specialist in his chosen field. He is a technical man whose efforts directly or indirectly are devoted toward the goal of greater economic wealth. The school curriculum is so designed that such professional attainment may be secured in the various specialized phases of the science. At the same time, however, every geologist is well-versed in the fundamental principles of geology and its related sciences through his school efforts. Some men, upon graduation, go out into commercial enterprises well-equipped and trained to apply the principles, facts, and theories which have a bearing on the distribution, mode of occurrence, and economics of our natural mineral resources. Others, still geologists in every sense of the word, elect to bend their efforts along research and instructional trends. Each must have met the requirements of a comprehensive course of study in geology before he reaches his objective. Indeed, it is upon graduation that the trends of special interest really begin to diverge. The man of commercial bent thereupon begins to visualize things largely from the practical standpoint whereas the researcher is still delving and probing into the subject in the more academic manner. The trained man in the field undertakes to carry on the analysis of the distribution and occurrence of valuable mineral deposits of lead, zinc, copper, gold, phosphate, cement, clay, etc. He is better able to reach the heights of his endeavors by having had the theory of geology as presented in our schools and universities. The unschooled man, by virtue of this fact, can never reach the higher level, regardless of his innate ability and judgment. The day of going out and discovering a mine which will yield ore from the grass roots down is essentially gone forever. Today, in the discovery of new mineral wealth, we must apply, as working tools, the theories and principles of our science.

The unschooled man can never, of course, in this day of extreme specialization, reach the heights attained by a specialist in research. The researcher is often working in science for science's sake, and also to the end that his findings will be of value to the man who has taken the other trail of strictly commercial practice. Although at the time the scientist discovers new principles there may not appear to be any direct commercial application, one usually soon develops and the practical man can thereby more readily search out the hidden riches of the earth.

As an illustration of this point, I might cite, as one example among many, the study of the paragenesis of metallic minerals. The economic geologist, working as a pure scientist in the beginning, and using his microscope and other laboratory facilities, early noted a certain uniformity and order in the sequence of deposition of many metallic minerals in nature. The commercial geologist, now that the day of discovering ore right at the earth's surface is largely gone, is employing these criteria more and more in his attempts to interpret and visualize sub-surface conditions of mining geology.

Inasmuch as geology is concerned chiefly with field interpretations and observations, it is frequently noted that the man who, through commercial experience, has cultivated a field technique, and can combine this experience with technical theoretical knowledge, not only then makes an outstanding research specialist, but, in addition, is often a splendid teacher. Students, who train under such an individual, tend to most readily grasp the interrelation of theory and practice and thereby can go on rapidly and steadily in later endeavors.

Here we note the close association of geography and geology. In fact, a geologist's education is not complete without

at least a fundamental training in geography and a knowledge of how the two studies may and do correlate and supplement each other. For example, what natural factors control our fertile soil areas, our natural boundaries, and economic mineral empires? What controls the occurrence and distribution of our watersheds and of our "dustbowl" areas? Certainly, the answers to these questions, together with many others which might be mentioned, are largely geographic in character but at the same time they are equally geologic. The processes involved have developed in and on the crust of the earth through the activity of natural geologic phenomena and agents. There is no question but that the occurrence of various geologic features closely parallel the geographic environment of man on the surface of the earth.

I am firmly convinced that true and total solution of our economic situation does not rest solely in the perfection of new geologic techniques nor in the discovery of new mineral deposits of oil, coal, silver, copper, lead, or phosphate. To a far greater degree it lies in our satisfactory solution of the current social problem. So it is with this thought in mind that I wish to present an analysis of the broader aspect of geology as we find it in the school curriculum. This is the phase which has to do with the natural inquisitiveness of the human mind and which sets man off as an animal apart from all others on the earth. Geologists have sometimes been called dreamers; it is said that they do not keep their feet on the ground and that they are prone to speculate and theorize too generally. If this be so, I claim it is a happy condition. For instance, Chamberlin and Moulton in developing their famous Planetismal hypothesis of Earth origin were parties, albeit unintentional perhaps, to such an order. Moulton, the physicist, and Chamberlin, the geologist, counterbalanced each other's efforts so that their work has become widely recognized. What happened? A true hypothesis is developed only through the correlation of facts and natural laws with imaginary ideas. It has been suggested that Chamberlin furnished many of the ideas. Moulton presented the physical facts with which they must agree. They are rightfully both entitled to equal credit for their achievement. I believe implicitly, and I am entirely sincere when I say that I think the solutions of material problems are not to be found in materialism, but are instead largely bound up in the appreciation and knowledge of the beauties of nature.

This is the appreciation that we gain from a study of the cultural phase of geology, and it is with this thought in mind that I suggest the ever widening adoption of the study of geology and geography in our secondary schools. The younger, more easily molded, mind is open and eager to grasp this study of our living sphere. For instance, the student observes and is brought to understand the devious but none the less controlled development of the wonders of nature on the earth's crust. We learn how and why the Grand Canyon of the Colorado River was formed, what Yellowstone, Craters of the Moon, Crater Lake, and other particular phenomena, mean in the earth scheme. We are romanticists in that we delve into the character of the center of the earth; how the earth originated, and how it fits into the infinite planetary system. We observe in fossils the wonderful evidence of past life on the earth, and we disturb and remove these forms from their burial ground of perhaps 500 thousand or 500 million years ago. In fact, we are in many cases the first creature that ever walked upon the face of the earth that has seen the fossilized animal since its burial day. We know why the dinosaurs no longer live upon the earth's surface — those tremendous beasts which grew so large that one form actually was forced to develop two nervous systems or brains so that his back legs and feet could keep coordinated and going in the same direction as his front limbs.

We speculate as to the former presence of land bridges joining two continents together. We study what makes our mountain ranges and why many of their highest peaks are now situated in areas which were formerly flooded by arms of the sea. We know that such is the case because we find fossils of marine animals trapped in the rocks of the mountain ranges. We know that the Salmon River, that famous "river of no return," was flowing over a land surface in its present direction and manner long before the present central mountain range of Idaho was uplifted. We observe the effects of glacial invasions and understand why peculiarities of such phenomena have resulted in the formation of an ideal locality for the Grand Coulee Dam.

In the study of geology, we lose ourselves not in the pursuit of material things to the degree that we do in the treatment of the awe-inspiring and magnificent wonders of the greatest history book of all, the earth's crust.

For this reason alone, and aside from the increase of our general knowledge, the geologist, or the person who merely studies geology as a natural science, are undoubtedly better men. The true geologist because economic enterprise and greed are tempered with the cultural aspects of the science, and the natural science student because he has been given an appreciation of the devious ways and grandeur of nature.

The Role of the Laboratory in the General Public Health Program

By DR. H. L. McMARTIN
Idaho Director of Public Health

Whenever one attempts to credit one or another service in a public health program with the success or failure of that program, he immediately finds himself in the midst of a heated controversy. With that thought in mind and with no intention whatsoever of belittling any specific service in the generalized program, I wish to outline to you briefly, a few of the important roles that a public health laboratory service plays in the public health program.

If we were to sit down and analyze the various services which make up the well-rounded public health program, we would immediately find two of these services whose value lies primarily in the concrete results produced. One of these is the laboratory service, the other is Sanitary Engineering. Both produce results which are easily accounted for, are tangible and are produced soon after the service is established. Of these two, the laboratory apparently gives the quickest results in a given time.

Public health laboratories in this discussion, will be considered those laboratories whose work is limited primarily to the bacteriological, serological and chemical analysis of specimens for the diagnosis of communicable diseases, tuberculosis, the venereal diseases and in the examination of water, milk, foods and sewage. This does not include those services generally done by private or commercial laboratories associated with the diagnosis of metabolic conditions or involving blood chemistry and the like.

Comparing a public health program to a football team, it would seem to me as foolhardy to plan a public health service without a well-functioning laboratory as it would be to send only part of a football team on the field to play an opponent with a complete team. It would be a tremendous handicap at the best, and would reduce the efficiency of the entire program to a great extent.

A laboratory is a valuable adjunct to every division of public health activity and constitutes one of the most important means of winning support for the entire program. In view of the fact that we are dependent on our practicing physicians for assistance in the control of the communicable diseases, tuberculosis, syphillis and the like, free diagnostic service by a well-functioning and well-equipped laboratory lends an important aid in securing the confidence and support of that profession for the entire public health program. I wish to emphasize that these services should be given without cost—since public health necessarily is a program not limited to a few or to a certain class, but one in which each service should effect the entire public health. There should be no discrimination because of ability to pay or not to pay.

The work of the laboratory might be divided into three parts:

1—The bacteriological, serological and chemical examination of specimens received for diagnosis or analysis.
2—The preparation and/or the distribution of vaccines, sera and drugs for the control and treatment of disease, and
3—Consultation services to physicians or members of other divisions in the department of health on problems of diagnosis and control of specific conditions, and to other laboratories within its influence on the matter of technique and standards of service.

In the field of communicable disease control, we find the laboratory to be of paramount importance, offering an aid in diagnosis, obtaining information regarding the prevalence of certain conditions in a specific locality and fur-

nishing a means of control. The laboratory furnishes a direct service to the practicing physician in this respect and assists the health officer or the epidemiologist in checking field studies of sources of infection. Although we feel that we should not depend entirely on laboratory reports for diagnosis, very often it confirms suspected diagnosis at such a time as to make treatment most effective. This is especially true in the diagnosis of diphtheria, meningitis and in the typing of pneumococcus, where specified sera given early, offers a valuable aid in treatment.

The epidemiologist in the department of public health is dependent in a great part for his success in field surveys on the assistance rendered to him by the laboratory. Close correlation of the activities of the field worker and the laboratory must be maintained if we are to expect accurate results and efficient control of any specified problem.

Sanitary engineering and the sanitation of food, water and milk would be badly handicapped without an efficient laboratory service to assist them in the chemical and bacteriological analysis of milk, water food and sewage. Oftimes the laboratory offers a clue to the solution to a difficult situation or corroborates evidence which may have been largely circumstantial. Here again, the laboratory offers a check to the sanitary engineer or the sanitarian in his field work. It is true that sanitation did a great deal for the public health before the era of bacteria and the science of bacteriology, but I am certain in my own mind that this field would have been limited seriously in the work that they have done, had it not been for the services of the bacteriologist and the chemist.

Whether a laboratory shall or shall not prepare vaccines, sera and other biologicals is a matter which can be discussed at great length. In all probability it will depend a great deal on the size of the laboratory, the number and quality of the personnel employed and upon the demand for such materials. It may be that the work involved in the diagnostic service takes up so much of the time of the personnel that the quality of the products turned out would suffer. Realizing that it is the primary duty of an official agency to distribute drugs and biologicals of unassailable quality, I feel that if sufficient time for the preparation of these biologicals by a trained person is not available, it is better that these products be purchased for distribution. All laboratories should be in an investigative frame of mind, and be ready, when the problem arises, to be in a position to take care of it.

Another, not unimportant, function of a good public health laboratory is that of evaluation of laboratory procedures used and the bacteriological and serological examination of specimens in diagnostic procedures. Whether or not original investigative work is carried on to raise the standards of laboratory procedure, the official laboratories should set standards of laboratory service which are above reproach, and it should use its efforts to raise the standards of all laboratory services, whether official or otherwise, within its influence. This function has been especially emphasized in the recent changes made in the serological examination of blood in the diagnosis of syphilis.

I have not meant to imply in this short discussion that a public health service could not exist without a laboratory any more than I would have you believe that the tail wags the dog, but I would like to emphasize how valuable a laboratory service can be to a program if it is used to its fullest capacity. The extent to which any laboratory will be able to carry out the various procedures generally expected of a public health laboratory, will depend on the size, and the capacity of that individual service. It would be foolish to expect a small laboratory to carry on intricate bacteriological and serological procedures where there is little demand for those services, but there are many services that it can perform efficiently

which will be of untold benefit to the local program.

We have found this service to be great value in the establishment of public health programs in Idaho. Coincident with the organization of local health units in four areas of our state, we have established a complete branch laboratory in the headquarters of the health unit, able to perform, with few exceptions, all the procedures that are carried out in the central laboratory. They have given the physicians a diagnostic service and consultation which has established a close working relationship between that profession and the general program, they have acted as a distributing agent for vaccines and biologicals, and for drugs for the treatment of syphilis. Likewise they have offered the local health officer great assistance in epidemiological surveys, and have given the sanitarian support in his work in the sanitation of milk, water and food.

Field Tests on the Effectiveness of Trashy Fallow and Contour Seeding in Controlling Erosion

By J. H. PARKINS*
Soil Conservation Service, Pendleton, Oregon

In the Athena area, the summer-fallow system of wheat production began about 1900. The greater part of the agricultural land receives from 14 to 17 inches of rainfall, most of which occurs during the winter months from October to May. As in similar areas, it is customary to cultivate summer-fallow with as many as four operations with the rod weeder to destroy weeds. These operations, plus those necessary to prepare a firm seed-bed, may bring the number of cultivations to six or seven from the time the stubble is plowed until the land is seeded to the next crop. This treatment results in a finely pulverized top soil subject to severe erosion. Too often, stubble burning has been practiced, leaving the field surface still more vulnerable to erosion.

During the last several years, tillage that keeps a mulch-like layer of stubble on the ground for erosion control in dry land wheat-growing areas has been gaining in favor.

The value of this work has stood out in succeeding seasons of demonstration. To a degree, it also has answered the farmer's problem of using the materials at hand to retard the loss of soil and water from fields exposed much of the year during summer-fallow operations or under the insufficient covering of pea crops or newly seeded winter wheat. Because of the winter rainfall and the condition of the ground after a seed-bed is prepared, erosion conditions are likely to be most severe during the winter and spring seasons following the seeding of winter wheat. As an added protective measure, contou rseeding also has been an acceptable practice in reducing soil loss. Thus far, trashy fallow and contour seeding have proved the most effective measures demonstrated in preventing soil and water losses under the wheat-summer-fallow system of cropping in this area.

Studies were undertaken in 1937 in the Eastern Oregon Area to determine the relative effectiveness of varying amounts of cereal crop residues and contour seeding versus up and downhill seeding in controlling soil and water losses under the conditions found on the Athena project.

Results to date indicate that contour seeding is considerably more effective than up and downhill seeding and that soil and water losses are lessened greatly if about 300 pounds of straw per acre are left on the surface at fall seeding time. By the same token, these losses are greater when the stubble is burned or plowed down. A combination of an adequate mulch of stubble on the surface and contour seeding, in normal years, gives a high degree of erosion control.

The stubble from the preceding small grain crop, when preserved on the surface, retards run-off and permits penetration of available moisture into the subsoil. In winter, this surface mulch of straw likewise retains some snow on the field, permitting it to melt in place and percolate to lower strata. Measurements have shown as much as three tons of straw remaining after harvest, and this whole amount has been used in preparing trashy fallow. By using the straw scatterer on the combine, straw is distributed in a manner making it less difficult to handle with available implements.

In these studies, comparisons were made by selecting four fields of approximately 10 per cent slope, of Walla Walla silt loam soil, having lost between 25 and 50 per cent of the top soil. Different tillage was used on each field and varying amounts of straw were left on the surface. Soil loss was estimated by measuring the length and cross section

*Assisted by Carl R. Freese and Bernard Ostness.

of the rills and calculating the amount of soil removed. The surface straw was estimated from the weight of three mill-acre samples gathered and dried at fall seeding time.

The results are as follows:

1937	Field No.	Surface Straw Per Acre	Soil Loss Per Acre	Direction of Seeding
	1	267 lbs.	2.9 tons	contour
	2	183 lbs.	6.75 tons	contour
	3	105 lbs.	18.21 tons	partly up & down slope
	4	37 lbs.	21.48 tons	contour
1938	1	1008 lbs.	0 tons	contour
	2	224 lbs.	31.7 tons	up and down
	3	177 lbs.	5.0 tons	contour
	4	31 lbs.	34.26 tons	up and down

It is very difficult in field tests of this sort to eliminate all the variables, and in the 1938 data this difficulty was especially noticeable. Field 2, for instance, had been worked more than any of the other fields, and the surface was finer. Nevertheless, the value of both straw on the surface and contour seeding, in general, is apparent. The 1937 data give a fair negative correlation between amounts of straw on the surface and soil loss.

The effectiveness of contour seeding is also apparent when comparing Fields 3 and 4 in the 1937 results. Although Field 3 had three times as much stubble as Field 4, there were only three tons difference in the soil loss between Field 3, seeded up and downhill, and Field 4, seeded on the contour.

Because the rill measurements do not give water loss comparisons, a one-fiftieth-acre plot for measuring run-off was established in the center of each field observed. All run-off water was collected and measured in tanks and its silt content determined. As the plots were only 80 feet long, the running water did not accumulate sufficiently to cause rilling, as it did in the fields; therefore, the total soil lost from each plot is considerably less than under field conditions. The comparisons between plots, however, again show the effectiveness of surface stubble and contour seeding.

The data are as follows:

1937	Plot No.	Per Acre Surface Straw	Per Acre Water Loss	Per Acre Soil Loss	Seeding Direction of
	1	267 lbs.	.04 in.	.046 T.	contour
	2	183 lbs.	.33 in.	.190 T.	contour
	3	105 lbs.	1.14 in.	3.276 T.	up and down
	4	37 lbs.	.93 in.	1.150 T.	contour
1938	1	1008 lbs.	.18 in.	.125 T.	contour
	2	224 lbs.	.96 in.	7.050 T.	up and down
	3	177 lbs.	.91 in.	1.415 T.	contour
	4	31 lbs.	2.00 in.	10.820 T.	up and down

Both contour seeding and trashy fallow appear to be of nearly equal effectiveness in these comparisons.

These findings are presented as the result of field observations during a two-year period on the Athena project. Their research value is not emphasized unduly, nor are these two years' results considered to be conclusive. The Soil conservation Service has found that the results are of value in the field program, in preparing tillage recommendations and in determining the relationship between contour seeding and residue utilization. The comparisons revealed in these studies appear to be sufficiently well founded to show the necessity for obtaining more exact determinations of this nature under more closely controlled research methods.

AUTHORS' ABSTRACTS
of
Papers Presented December, 1939,
at the Meeting of
Northwest Scientific Association

Chemistry Abstracts

Aryl Magnesium Alkoxides

By H. JASS
Department of Chemistry and Chemical Engineering
State College of Washington

Aryl magnesium alkoxides, thought to be formed as inert by-products in certain coupling reactions, were prepared in pure form by the action of alcohols on diarylmagnesium compounds. The mechanism of the reaction was studied and the reactivities of the compounds toward various reagents were determined. The results indicate that the compounds of the type

Ar - Mg - O - R

are less active than ordinary Grignard reagents.

Indebtedness to H. R. Snyder for the privilege of presenting this paper is acknowledged.

Crossed Cannizzaro Reaction

By ROBT. B. CALLISON and S. E. HAZLET
Department of Chemistry and Chemical Engineering
State College of Washington

A detailed study of the crossed Cannizzaro reaction has been made. The aldehydes used were benzaldehyde and furfural. Methods of analysis of the reaction mixtures have been studied. The results indicate that the furfural is oxidized to a greater extent than the benzaldehyde; consequently the yield of benzyl alcohol is greater than that of furfuryl alcohol.

The furan compounds used in this study were kindly supplied by the Quaker Oats Company.

Synthesis of Substituted Mandelic Acids

By D. A. STAUFFER
Department of Chemistry and Chemical Engineering
State College of Washington

Further applications have been made of the general synthesis of substituted mandelic acids in which a substituted benzene is condensed with ethyl oxomalonate to form an intermediate compound. This yields the mandelic acid upon hydrolysis. With diphenyl, the corresponding mandelic acid was obtained, but the bromotoluenes formed intermediate products which could not be hydrolyzed. In addition, several acyl derivatives of a number of mandelic acids have been prepared.

Acknowledgment is made to J. L. Riebsomer for permission to present this paper.

Substitutions in Esters

By HARRY KORNBERG and S. E. HAZLET
Department of Chemistry and Chemical Engineering
State College of Washington

Continuing our studies on substitutions in esters, we have found that the acetates of **p**- and **o**-phenyl phenol are brominated first in the ortho or para positions with respect to the acyloxy group. This behavior is analogous to that of the phenols and no steric effects were noted as in the cases of the benzoate and benzenesulfonate previously studied.

Work has been started on the meta isomer. The **m**-phenylphenol used was generously furnished by the Dow Chemical Company.

ABSTRACTS OF INTEREST TO AGRICULTURE

The Results of Feeding Morning Glory (Convolvulus arvensis) Seeds to Ringneck Pheasants and Hungarian Partridges

By CARL R. FREESE and BUELL R. CRANE
Pendleton, Oregon

This paper dealt with the efficiency of two Ringneck pheasants and two Hungarian partridges in the digestion of unscarified seeds of Morning Glory, **Convolvulus arvensis,** fed in gelatin capsules, and in open containers both mixed with grain and unmixed. The birds were fed daily for two months, under confinement. A total of 11,212 seeds were fed in all the trials. Digestion of the seeds when force fed ranged from 89.4% to 99%. Digestion of the seeds eaten from open containers ranged from 95.1% to 100%. Germination of the seeds was not affected by passing through the digestive tract of the birds, when passed whole.

When given a choice between Morning Glory seed and grain, the birds did not eat the weed seed freely.

There was a tendency for the birds to hold the seed in their gizzards for some time, and thereby to substitute Morning Glory seed for grit.

The paper did not deal with the crop contents of birds captured from the wild.

The Use of Forage-Acre Requirements in Grazing Surveys

By R. R. HUMPHREY
Soil Conservation Service, Spokane, Washington

Surveys to determine best grazing use of rangeland have only a limited value unless accompanied by figures showing the amount of forage needed to support an animal for a given period.

Various factors are involved in determining this forage-acre requirement, chief among which are: the amount of unmeasured forage present; differences in nutrient value of different types of forage; size of grazing animals; condition of range; variations in estimates made by different survey parties; differences in elevation, exposure, and precipitation; differences in slope; variations in forage-production potentials of different soils; erodibility of soils; grazing practices used; uniformity of forage utilization.

A consideration of these points at the time of making a range survey will facilitate development of graing plans that will permit the rancher or stockman to make most productive use of his grazing land and at the same time provide maintained, often increased, growth of range forage.

Toxicity of Sodium Chlorate in Three Yakima Valley Soils

By W. A. HARVEY
Department of Agronomy, State College of Washington

Laboratory experiments indicate that the rate of application of sodium chlorate used as a weed killer is dependent upon soil fertility as well as upon the weed species. More sodium chlorate is required to kill a particular weed on very fertile soil than on less fertile soil. Applications of sodium chlorate on soils with a high alkali content are apt to result in undesirable changes in the soil. Soils so treated may become tough, tend to cake when drying out and become almost impossible to cultivate.

Contrasting Density Changes of Poa Secunda and Bouteloua Gracilis in Eastern Montana Through Seven Years, Including the Extreme Droughts of 1934 and 1936

By W. LUTHER NOREM
Missoula, Montana

The most striking change in the vegetation on the ranges of eastern Montana during the recent prolonged drought period beginning in 1931 was the tremendous decrease of such important grasses as grama, buffalo and wheatgrass. In the spring of 1937, the density of these grasses was less than 1/10 of what it had been in 1933, but with the return of more favorable moisture conditions during the last two or three seasons, recovery has been rapid. Grama alone increased more than four times in density from its low point in early 1937 during the two successive favorable seasons of 1938 and 1939.

In direct contrast to this down and up trend of the other grasses has been the great increase of Sandberg bluegrass during the dry years and its decrease during the more favorable 1938 and 1939 seasons—wet years that followed. Strong seeding habits and the ability to complete its growth on the early spring moisture coupled with the habit of remaining dormant during the dry summers enabled it to move in on soil vacated by the other grasses. Now that competition is becoming more keen, it is again fading into the background.

The value of the bluegrass during the drought period has been tremendous. It has slowed erosion of denuded soils and as an early spring feed it has born the brunt of grazing in the critical period while other grasses were getting starte.d.

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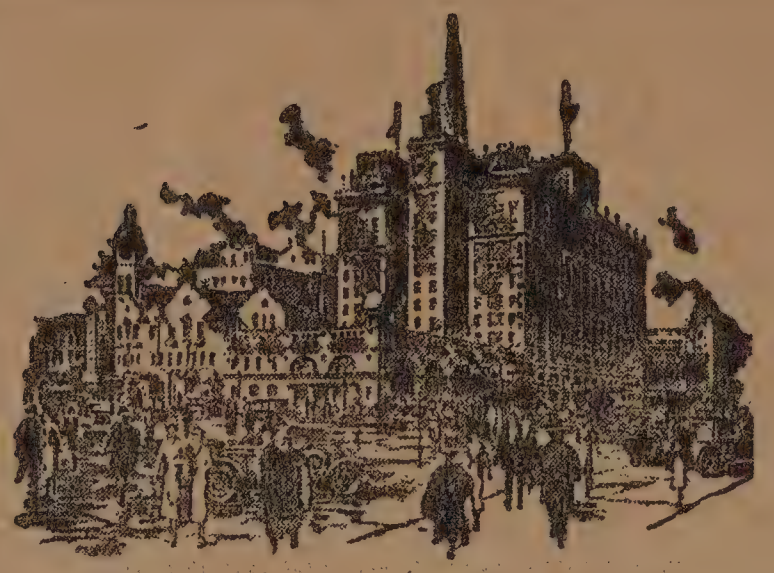

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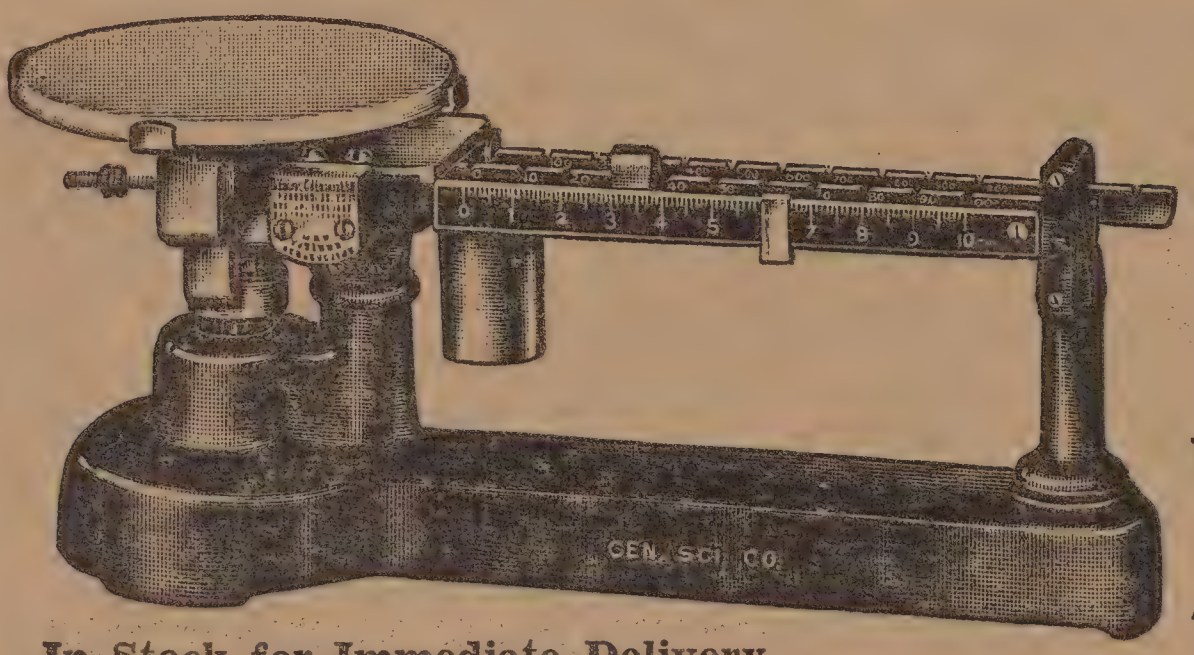

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E. M. Keyser

In Memorium

The Northwest Scientific Association suffered a serious loss in the death of E. M. Keyser on February 24 in Spokane. Mr. Keyser had been a member of the Association since its organization and at his death was serving as trustee. For several years he was chairman of the board of trustees and helped greatly to plan and assist worthy research projects in the Pacific Northwest. For many years Mr. Keyser served on the local committee in charge of arrangements for the annual meetings of the Association including the meeting of last December. Mr. Keyser presented several papers before the Association and was the author of numerous articles published in Northwest Science, the U. S. Weather Review and other publications.

Mr. Keyser had been associated with the Weather Bureau of the Government for nearly 40 years. Since 1920 he was head of the Spokane Office of the Weather Bureau and while serving in this capacity became widely known throughout the Inland Empire. Previously he worked in the Canal Zone for nine years and in other places. Mr. Keyser had retired from service less than a month before his death.

Surviving are his widow, two sons and a daughter. To these and his many other friends and associates, the members of the Northwest Scientific Association offer their sincere condolences.

OTIS W. FREEMAN.

An index of the contents of the first ten volumes of NORTHWEST SCIENCE and separate indexes for volumes 11, 12, 13, and 14 can be secured gratis by members of the Northwest Scientific Association upon request from O. W. Freeman, Editor, NORTHWEST SCIENCE, Cheney, Washington.

MAR 21 1941

Association Officers

The following officers for the Northwest Scientific Association to serve during 1941 were elected at the December, 1940, meeting.

President—J. H. Christ, Director, Soil Conservation Service, Pacific Northwest Region, Spokane.

Vice President—J. Warren Severy, Montana State University, Missoula, Montana.

Secretary-Treasurer—W. B. Merriam, Oregon College of Education, Monmouth, Oregon.

Trustees—Dr. R. F. E. Stier, Spokane, Chairman; John B. Appleton, Assistant Director, Northwest Regional Council, Portland, Oregon; E. H. Steffen, Washington State College; W. H. Cone, University of Idaho; Thomas Large, Spokane; W. A. Rockie, Spokane; Ernest McCulloch, Washington State College.

Honorary Trustees—R. L. Rutter, Spokane; Stanly A. Easton, Kellogg, Idaho.

Sectional officers elected for 1941 include the following:

Bacteriology and Public Health—Chairman, Dr. Howard Lundy, Pullman, State College of Washington; secretary, Haakon Bang, Pullman, State College of Washington.

Engineering—Chairman, C. L. Barker, Pullman, State College of Washington; secretary, James G. McGivern, Spokane, Gonzaga University.

Social Science—Chairman, O. K. Dizmang, Spokane, Whitworth College; secretary, Lee J. Cronbach, Pullman, State College of Washington.

Geology-Geography—Chairman, Dr. Charles D. Campbell, Pullman, State College of Washington; secretary, Dr. Julian D. Barksdale, Seattle, University of Washington.

Botany-Zoology—Chairman, Dr. W. R. Hatch, Pullman, State College of Washington; secretary, Dr. Hubert Eastlick, Pullman, State College of Washington.

Forestry—Chairman, C. Svendby, Spokane, Soil Conservation Service; secretary, C. R. Patrie, Spokane, Indian Forest Service.

Chemistry Physics Mathematics—Chairman, Stewart E. Hazlet, Pullman, State College of Washington; secretary, H. S. Owens, Moscow, University of Idaho.

Soil Conservation—Chairman, G. Orien Baker, Moscow, University of Idaho; secretary, C. E. Deardorff, Spokane, Soil Conservation Service.

Publications of the Northwest Regional Council

MEN AND RESOURCES. Northwest Regional Council, Portland, Oregon, 1941. Price 75 cents.

Men and Resources published by the Northwest Regional Council is a most valuable publication. Every thinking person in the United States should be concerned with the problem of the resettlement of migrants, especially those who have been forced by drought or other causes to leave their former homes. The migration to California received most attention. Then came a survey of the Northwest by the Northwest Regional Planning Commission, the results of which were issued in mimeographed form as an interim report under the title "Migration and the Development of Economic Opportunity in the Pacific Northwest." The edition was limited and was unavailable to many interested. To meet the demand of the general public and of educators for information on the subject the Northwest Regional Council has issued a concise, attractively printed, paper covered book on the problem. In the space of seventy pages this publication offers in non-technical language a comprehensive abstract of the important material covered in the interim report, including ten useful maps and figures. Besides the text there are eleven additional pages that give a useful list of selected references for the benefit of those wishing to secure further information on the Northwest in general or specific resources within the area. **Men and Resources** is worthy of careful reading and leaves the impression that the approximately 200,000 migrants who came to the Northwest in the last decade in hopes of establishing permanent residence with satisfactory living standards can be absorbed with benefit to the region. The limits as well as the possibilities for future development are fairly stated.

Plant Succession on Subalpine Grasslands as Affected by Livestock Management

ELBERT H. REID
Assistant Range Examiner
Pacific Northwest Forest and Range Experiment Station
U. S. Forest Service, Portland, Oregon

A grassland type of vegetation is common to ridgetops and open slopes of the Hudsonian life zone in the Wallowa and Blue Mountains in Oregon and the Cascade Range in Washington. On these areas, which occur between 6,000 and 9,000 feet elevation in and above the spruce-fir belt, the green fescue or mountain bunchgrass **(Festuca viridula)** association is probably the most extensive climax type.

It is hard to conceive of a more stable condition of vegetation and soil than that of the green fescue climax under natural conditions. Green fescue, a bunchgrass peculiar to the Pacific Northwest, grows in nearly pure stands, its dense foliage and extensive fibrous roots apparently enabling it to crowd out all other indigenous species. Usually the fescue plants cover at least half the ground surface. Secondary plant species under these conditions are represented by occasional plants growing between the fescue bunches. The most common secondary species are needlegrasses (**Stipa columbiana** and **S. lettermani**), squirreltail **(Sitanion hystrix)**, spiked trisetum **(Trisetum spicatum)**, sedges **(Carex spp.)**, lupines **(Lupinus spp.)**, western yarrow **(Achillea lanulosa)**, pentstemons **(Pentstemon spp)**, and eriogonums **(Eriogonum spp.)**. An outstanding characteristic of the climax condition is the effectiveness of the deep, extensive root systems in binding the soil. Although green fescue is typically a bunchgrass the spaces devoid of vegetation between the green clumps usually are not bare soil but, rather, consist of dead green fescue root crowns and root masses that have not yet decomposed. This gives a sod-like character to the plant association which is an effective natural means of preventing soil erosion.

The green fescue climax developed in a habitat where the influence of foliage removal by grazing animals was limited to that from native herbivores such as deer, elk, and rodents. Therefore, when such areas are also grazed by domestic livestock a factor foreign to the natural habitat is introduced. The degree to which grazing by domestic livestock influences plant development depends largely upon the severity of the repeated foliage removal and the effect of the increased amount of trampling on the vigor of each plant species occurring in the type. Studies made by the Pacific Northwest Forest and Range Experiment Station show that of the plant species occurring in the green fescue climax, green fescue itself is by far the most palatable both to cattle and to sheep. For example, on a range where sheep grazed off 45 percent of the green fescue herbage, they utilized 15 percent of the intermixed needlegrass, 8 percent of the western yarrow, 3 percent of the lupine, and 13 percent of the pentstemon. As the percentage of herbage removed from the fescue plants is greater than from any of the secondary species its vigor is more seriously affected by grazing of domestic animals. Because of the importance of green fescue in the climax type, marked changes in the plant cover will occur if continued grazing reduces its vigor to the point where it can no longer compete successfully with the associated vegetation.

When the fescue plants are weakened or killed by recurrent overgrazing there is an influx of other grasses, weeds, and shrubs which become established on the blocks of topsoil originally held together by the fibrous roots of the fescue or

the dead root masses. The invading species are determined largely by the plants in the vicinity which furnish a seed source. The most common invaders, species characteristic of the second weed stage, are needlegrasses, western yarrow, whorl phlox **(Leptodactylon nuttallii),** lupine, eriogonum, glandular cinquefoil **(Drymocallis glandulosa),** sagebrush **(Artemisia tridentata),** pentstemon, and squirreltail. Invading species may form pure stands, as is often the case with needlegrass, or mixed stands of a few to many species.

Whereas the effect of overgrazing results in an unnatural balance in the plant cover which encourages retrogression towards the second weed stage, excessive trampling by livestock results in even more serious processes of plant depletion. Any breaking up of the sod-like root masses in the bare spaces between the plant bunches results in accelerated soil erosion. During erosion process soil removal is usually so rapid as to prevent establishment of any vegetation except a sparse cover of rudimentary plants such as horsemint **(Agastache urticifolia),** pussypaw **(Calyptridium umbellatum),** phacelias **(Phacelia heterophylla** and **P. alpinum),** kitchenweed **(Gayophytum sp.)**. and knotweed **(Polygonum douglasii).** With the weakening of the soil-binding live green fescue roots, soil erosion accelerates, deepening the surface level between the blocks of topsoil and abrading their sides. Once started, this process continues until it becomes partially stabilized by the formation of an erosion pavement. The exposure of their roots by soil erosion weakens the green fescue plants to the extent that needlegrasses, whorl phlox, western yarrow, lupine, and other plants encroach on the remaining root-bound soil or upon soil deposited on the uphill side of these stools. After an erosion pavement forms and soil movement slows somewhat, some species such as needlegrass, eriogonum, and lupine which are adapted to the poorer, less stable soils spread out from the plant stools, while others, including fleeceflower **(Aconogonum phytolaccaefolium),** phacelia, and horsemint come in from outside areas. Together these form the basis for a new stand. Green fescue and other plant species that are dependent upon the stability and fertility of the climax soils disappear from the cover when these conditions no longer exist. Most often with poor livestock management the weakening of the fescue stand by overgrazing and the soil erosion resulting from trampling occur together. This is particularly true on sheep range.

The end result of these changes occurring in subalpine grasslands due to the influence of overgrazing and excessive trampling by domestic livestock upon plant composition is a needlegrass-weed type typical of the secnod weed stage. Whereas the climax vegetation usually occupies more than half the ground surface, the vegetation of the needlegrass-weed type occupies approximately one-tenth the ground surface. Compared to the sod-like, root-bound topsoil of the climax conditions, the needlegrass-weed type grows on loose, unstable soils.

The importance of the soil losses and changes in plant cover occurring with the retrogression of the green fescue climax can be gaged by their effect on grazing and watershed values on these areas.

Studies based upon the density, composition, and forage value of the plants and upon livestock use history of range areas in the climax and depleted conditions indicate that retrogression of the green fescue range from the climax to the second weed stage is accompanied by a loss of approximately nine-tenths of the potential grazing capacity. The change in watershed values accompanying the retrogression is not known. However, research by Forsling,[2] Craddock,[1] and Pearse[3] has demonstrated that fibrous-rooted plants characteristic of grassland climax conditions are more effective in preventing soil erosion and in promoting water absorption by the

soil than are the semi-fibrous and tap-rooted plants of the lower successional stages. Since the change from the green fescue climax to the needlegrass-weed stage represents a change from the extensive, fibrous root system of the fescue to the less extensive, fibrous roots of needlegrass and the semi-fibrous and tap roots of weeds, it can be assumed that the watershed values of these depleted grassland areas are correspondingly impaired.

In view of the studies showing that depleted subalpine grasslands in the second weed stage are capable of furnishing forage for only one sheep where the climax condition for the same area would be capable of furnishing forage for 10 sheep, the question arises whether the climax condition can be re-established. The time required and the conditions of use under which depleted areas can be revegetated naturally depend upon the amount and quality of the residual soils and the vigor and composition of the residual vegetation. One thing is certain; the factors which caused the original retrogression—recurrent overgrazing and excessive trampling—must be eliminated before any improvement can be expected. They will also have to be eliminated if further plant retrogression and soil losses are to be prevented. If these factors are removed, the natural forces which created the original climax can be expected to return the area towards the climax. Sampson,[4] working in the Wallowa Mountains, has shown that with a sufficient remnant stand of green fescue remaining to furnish a seed source the green fescue stand can be re-established by employing methods of livestock management which give consideration to the growth requirements of the fescue. Other conclusive evidence points to the fact that depleted green fescue ranges can be revegetated. For example, a fenced enclosure on the Wenatchee National Forest seriously depleted by cattle grazing, returned to a near climax condition after being fenced against excessive grazing for eight years.

The prospect of a 90 percent loss in grazing capacity should be sufficient economic reason to encourage careful utilization of range in the climax condition. Likewise the prospect of an equally great improvement in the forage yield should be sufficient incentive to encourage programs of livestock management which will foster such improvement. The primary requirements of livestock management both on areas that are to be retained in the climax condition and on areas where it is desired to allow the natural processes of plant competition and plant succession to return the area towards the climax condition are: (1) That trailing of livestock which disturbs the soil and starts soil erosion be minimized, and (2) that the periodic foliage harvest by cattle or sheep not interfere with the life functions of the green fescue plants.

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Migration and Economic Opportunity in the Pacific Northwest

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Migration to the Pacific Northwest[1] has been a continuing process for more than a century. Before 1930, however, the assimilation of newcomers was a relatively simple matter. In the earlier years free or cheap land suitable for settlement was abundant, and a comparatively rapid economic development provided employment opportunities. But in spite of the relatively small population now in the region—in 1930 it was 3,500,000, or 2.8 per cent of the national total—the accelerated influx of people seeking a livelihood during the past decade has exceeded the absorption capacity. No longer is there an abundance of free good land awaiting the plow. That was all preëmpted long ago. Lumbering and fishing are no longer expanding industries. In fact, the widespread economic depression was accompanied by serious unemployment among those already resident in the region. The large number of newcomers aggravated an already bad situation. Few of these, whether urban or rural, arrived with enough funds to purchase good farmland, even if this had been available, or to tide them over an extended period of unemployment and readjustment. Consequently, the serious economic and social problems confronting the Northwest have national as well as regional implications.

Number and Source of Migrants.

The exact number of migrants who arrived in the Northwest between 1930 and 1939 is not known. But several sample surveys have been made on the basis of which the intensity of the movement has been calculated.[2] It is estimated that 620,000 persons were living in Washington, Oregon, and Idaho in the spring of 1939 who had been living in another state in 1929. Of this number, 160,000 were persons who had moved from one state to another within the region—intraregional shifts. The remaining 460,000 represent the total influx from states other than Washington, Oregon, and Idaho. Data for Montana are lacking; but it may be assumed that the situation there was similar to that in other parts of the region. It should be noted that the figure 460,000 does not represent the net gain in population 1929-1939, since no allowance was made for births, deaths, or departures during that period.

The normal rate of migration was accelerated during the period 1934-1937 and reached a peak in January, 1938. Since that time, however, the movement has definitely slowed down to the pre-1934 rate.

It is generally considered by competent authorities that earlier movements to the Northwest were numerically greater than that during the last decade. The movement of 1920-1930 is estimated at 440,000, which is only slightly less than that of 1930-1939.[3] The net gain during the rapid expansion of the lumber industry, 1900-1910, was much greater. A study of population data reveals that 50 per cent or more of the resident population has always been composed of people born outside the region.

The map, Figure 2, gives an idea of the main areas from which migrants have come. It was constructed on the basis of a study of 45,211 families. If the sample is representative, it is evident that the Northern Great Plains and the North Central States have contributed the largest numbers—25 per cent and 14 per cent respectively. Large numbers seem to have originated in the vicinity of the large cities of these

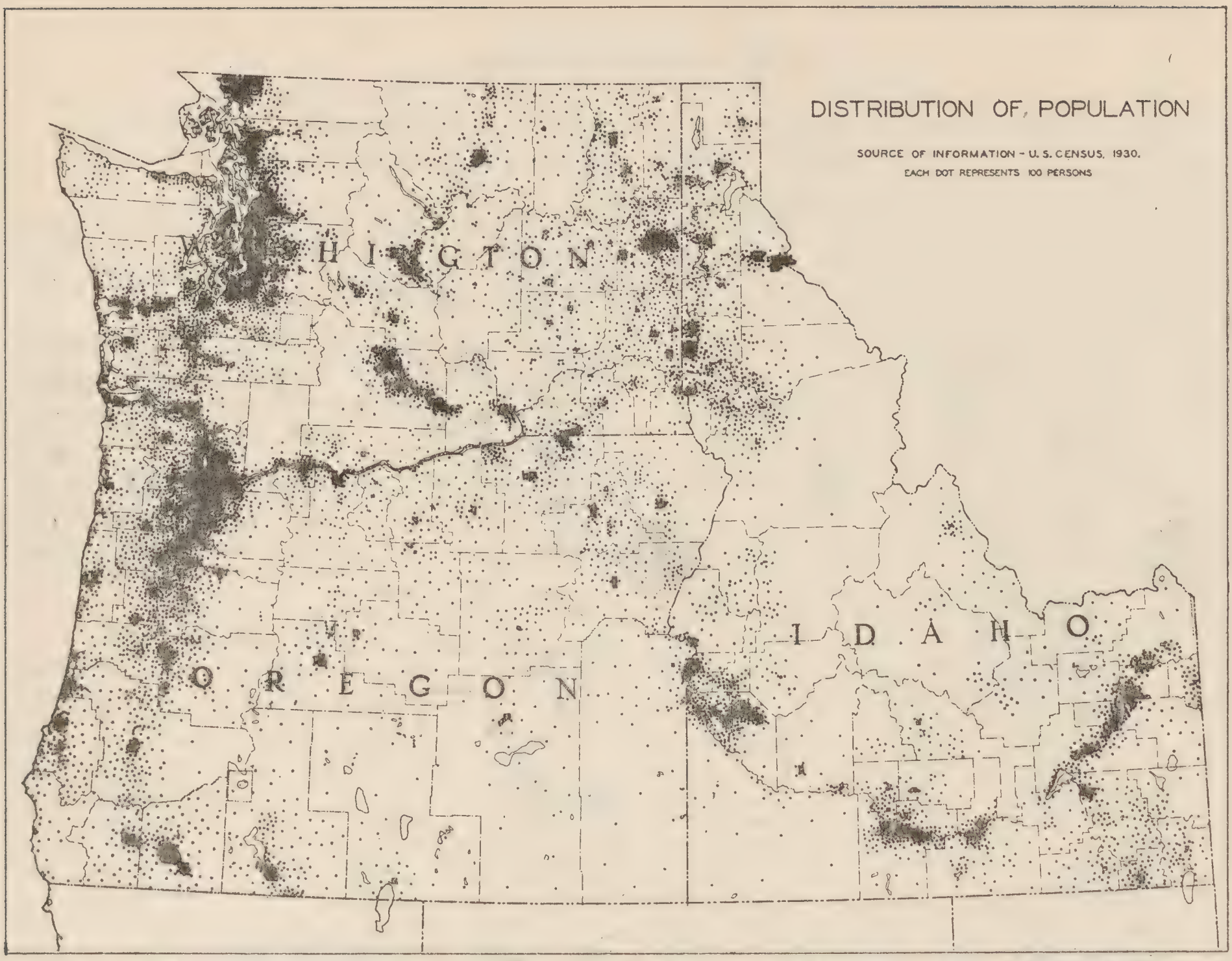


Fig. 1. Distribution of population in the Pacific Northwest, 1930. One dot represents 100 persons. (Pacific Northwest Regional Planning Commission.)

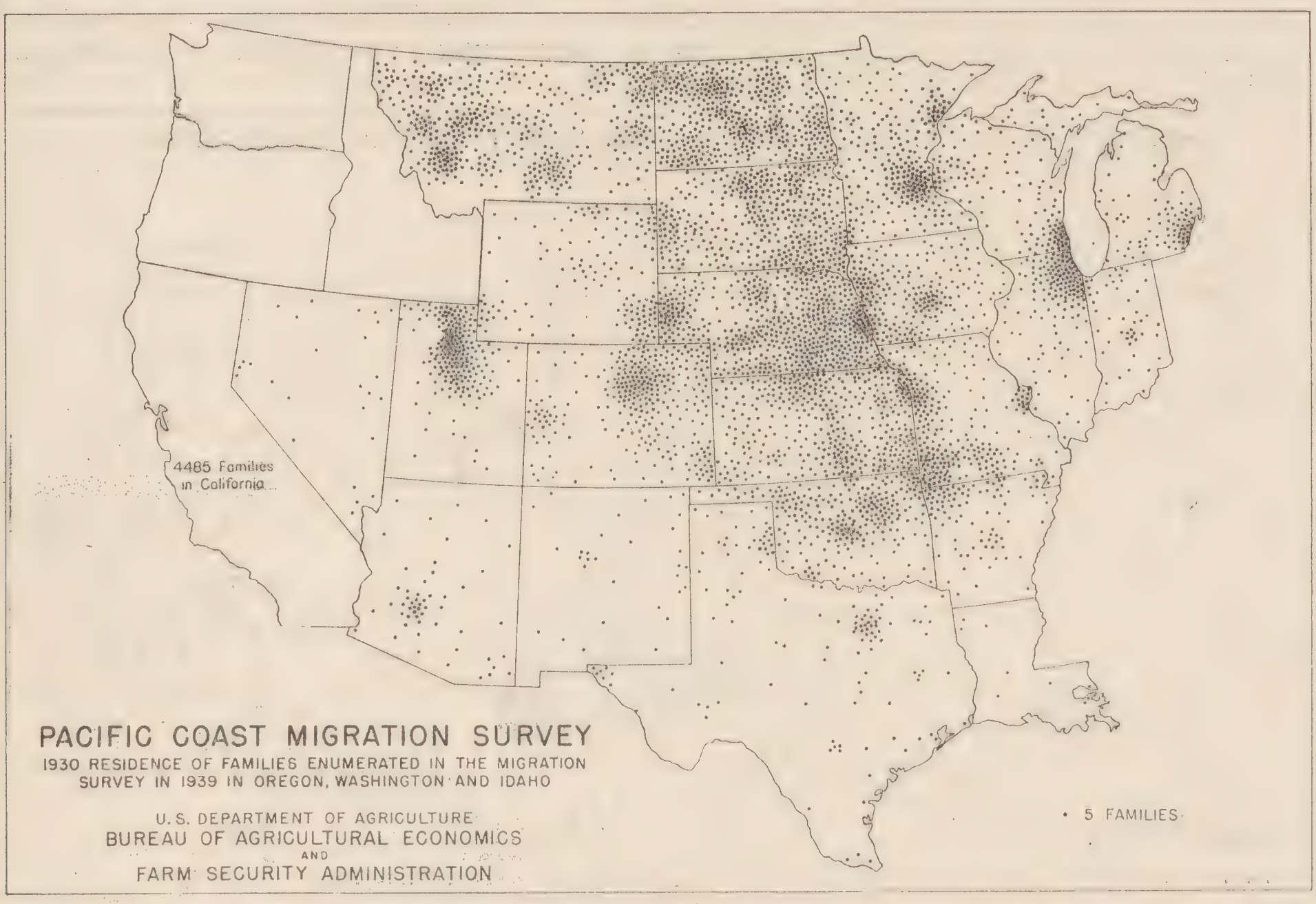

4485 Families in California
PACIFIC COAST MIGRATION SURVEY
1930 RESIDENCE OF FAMILIES ENUMERATED IN THE MIGRATION SURVEY IN 1939 IN OREGON, WASHINGTON AND IDAHO
U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS
AND
FARM SECURITY ADMINISTRATION
• 5 FAMILIES

Fig. 2. Origin of migrants to the Pacific Northwest. One dot represents five families. The map shows the residence in 1930 of the enumerated families that moved to the Pacific Northwest between January 1, 1930, and the spring of 1939 from states west of the Mississippi River and Ohio; those living in Pacific Coast States in 1930 are omitted. The families shown includes about 57 per cent of the total number enumerated. (Labor Division, F. S. A., Regional Office, Portland, Ore.)

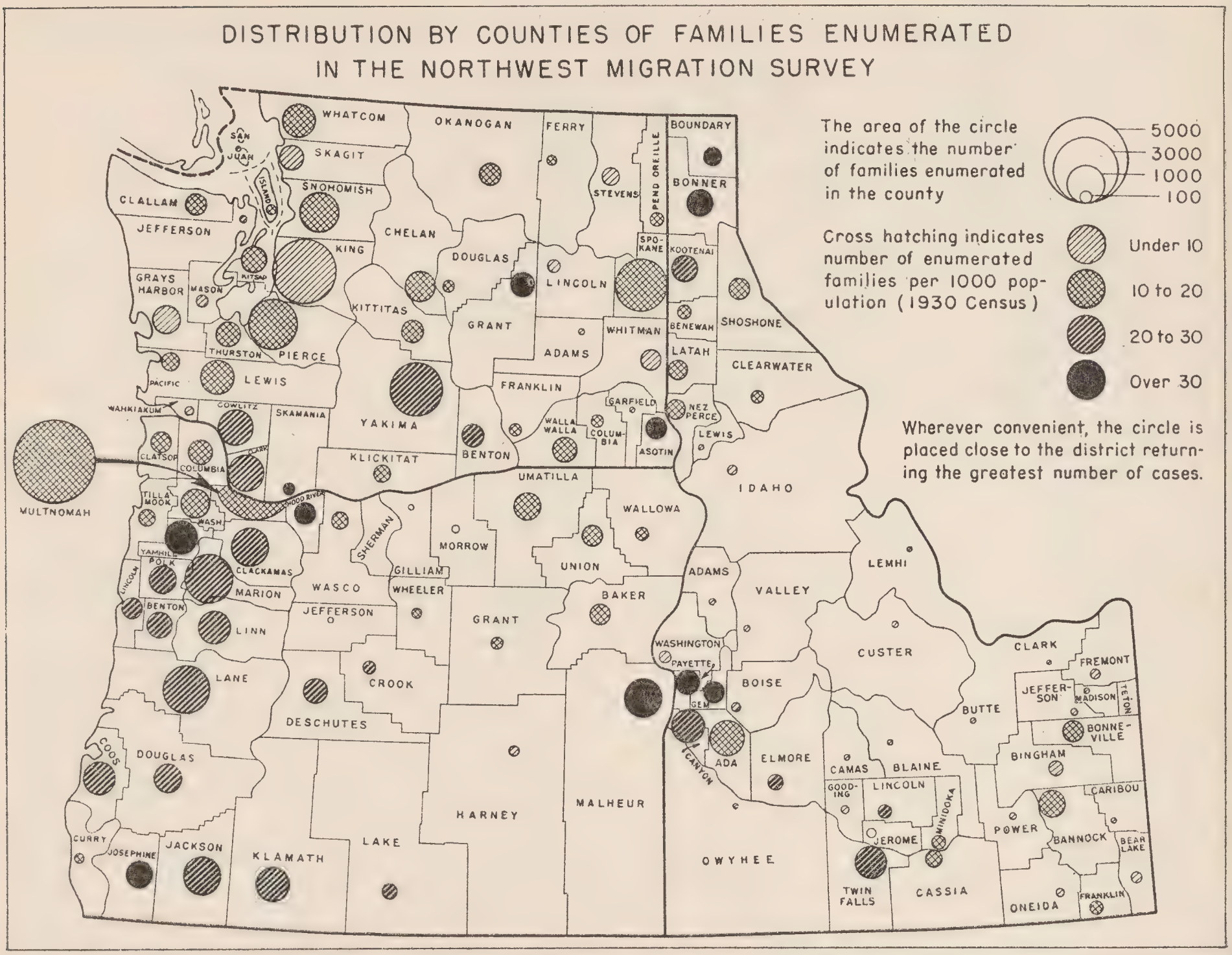


Fig. 3. Distribution by counties of families enumerated in the Northwest Migration Survey. (F. S. A., Regional Office, Portland, Ore.)

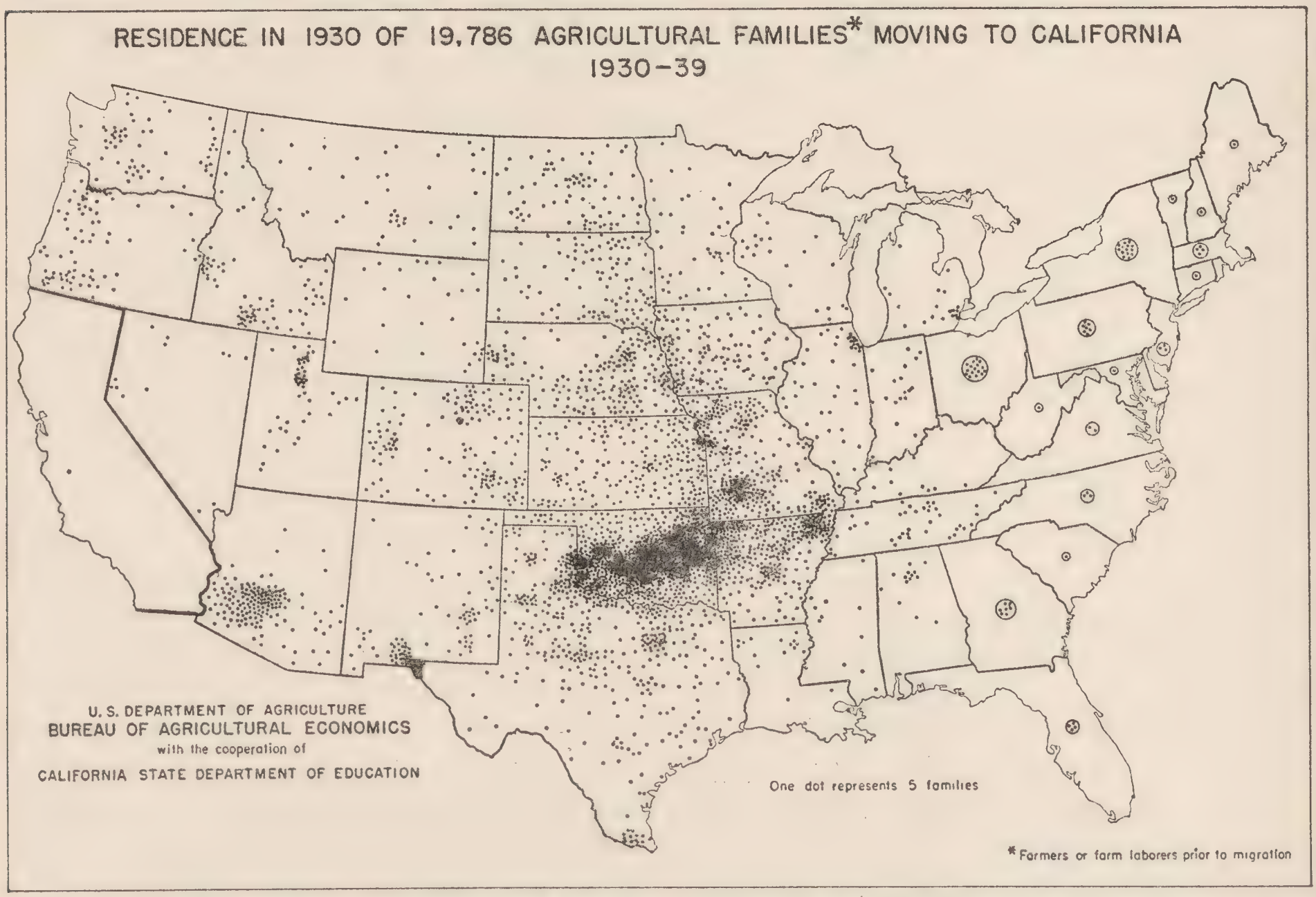
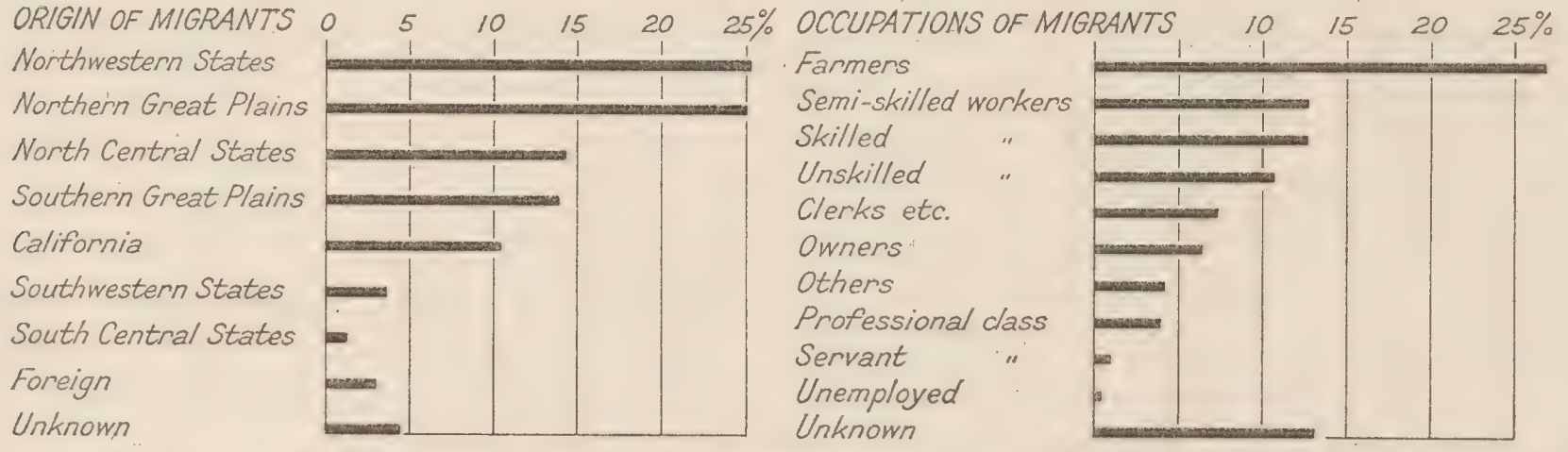

RESIDENCE IN 1930 OF 19,786 AGRICULTURAL FAMILIES* MOVING TO CALIFORNIA
1930-39
U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS
with the cooperation of
CALIFORNIA STATE DEPARTMENT OF EDUCATION
One dot represents 5 families
*Farmers or farm laborers prior to migration

Fig. 4. The origin of agricultural families migrating to California in 1930-1939. This map is given for comparison with Figure 2.

regions, such as Denver, Omaha, Minneapolis, St. Paul, and Chicago. In general, lines of movement have tended to coincide with the main east-west routes; for only 15 per cent of the sample moved direct to the Northwest from the Southern Great Plains and the South Central States. Most of those from the latter region went first to California. The data indicate that only 10 per cent originated east of the Mississippi, that about 14 per cent moved into the Northwest from California and the South-



Figs. 5 and 6. Graphs showing regional origin of migrants to the Pacific Northwest (left) and their former occupational groupings (right). (Data from F. S. A., Regional Office, Portland, Ore.)

western States, and that 25 per cent were residents in Washington, Oregon, or Idaho before 1930.

Acceleration of Migration.

A combination of interrelated conditions, partly physical and partly economic, accelerated the westward movement in 1934-1939. Not only did the unusually severe drought in the Great Plains region cause the failure of crops and the destruction of livestock, but wind erosion and dust storms ruined much land. Agricultural maladjustments in a region where the rainfall is always relatively light and unreliable had increased the hazards of farming and grazing. Overgrazing, the continued cultivation of soil-depleting crops, and the failure to adopt soil-building rotations had paved the way for the excessive wind erosion that accompanied the drought. Had the drought occurred a decade earlier, when industry was thriving, many would have gone to the industrial centers of the East, which in the past have absorbed most of the normal surplus ruural population. But the depression, with which the drought coincided, had greated serious urban unemployment, and many city dwellers were turning to the land as a possible means of livelihood. Depressed agricultural prices increased the difficulties of farmers everywhere, and many were forced to vacate their land. The agricultuural situation was reflected in the distress in urban communities dependent on the adjacent farming population. Rural unemployment also increased with the expansion of mechanized farming. To many migration seemed the only way out.[4]

The West had been a promised land for settlers from 1849 on—in fact, the traditional concept still persists to a certain degree. Those in distress looked, as in the past, to the West for an opportunity to begin life anew. Especially to those resident in the relatively near, drought-stricken Northern Great Plains did the Pacific Northwest, with its moderate climate, offer multiple attractions. The main highways led directly westward. The culture pattern was not unlike their own—a vital factor to people seeking to make a new start. Similar considerations attracted people from the Middle West and the Northeast.

Unfortunately for these modern migrants, however, the Northwest is no longer a frontier; it is a developed region with a rather specialized economy.

The migrants to the Northwest constitute a fair cross section of the population of the region whence they came.

About half are agriculturists—farmers or farm laborers. The remainder include representatives of the various skills, trades, and professions that make up the personnel of an average community. Most of the adult newcomers are less than 45 years old—people in the most productive years of life. Studies show that most of them are financially responsible when employed and are not by nature "drifters." Their assimilation is largely an economic problem.

Distribution of Migrants.

Rugged terrain and arid or semiarid conditions have restricted settlement in the Northwest to the humid lowlands west of the Cascades and to irrigated districts in the dry, intermountain area. The population is "clustered," and the economic life is concentrated in a few relatively small areas. The distribution of drought migrants conforms, in large part, to this pattern of occupancy. They are most numerous in the rural districts and small towns of the Willamette Valley, the Puget Sound lowland, the Yakima Valley, the Palouse area around Spokane, and the middle Snake Valley. Smaller irrigated valleys elsewhere also show new population. Large numbers have drifted into remoter areas such as the cutover lands of northern Idaho and western Montana.[5] Most of the agricultural group, too poor to purchase or rent the few improved farms available, have taken over submarginal land—cutover areas or abandoned farms where soil, slope, drainage, and water supply are unfavorable. A survey of 20,000 migrants who settled in Washington, Oregon, and Idaho between 1930 and 1935 revealed that only 2.8 per cent were able to rent or purchase reasonably productive farms, 24 per cent took up abandoned farms, and 48 per cent settled on unimproved land, largely cutover areas. In almost all cases the cultivated acreage is too small to provide an immediate living, and some other source of income or relief is imperative. By 1939 about 12 per cent of the farmers and 7 per cent of the farm laborers had succeeded in settling on the land. About 20 per cent of the migrants were engaged in unskilled labor, and 8 per cent were employed on W. P. A. projects. Data regarding skilled and professional workers are not available.

More than half of the recent rural settlement has occurred in areas where land-use problems are acute. Many would-be settlers have taken up small acreages of cutover land in western Washington—Kitsap County, for example. Without mechanical equipment clearing the land of stumps is extremely arduous and slow, and the farmer cannot prepare an adequate tillable area and bring it into production before his funds are exhausted. Most of the holdings are too small and the soils thin, poor, quickly depleted, and unsuited to agriculture. Even where the acreage is adequate, the expense of mechanical clearing, $150 to $300 an acre, is beyond the farmer's small means. In an effort to assist such settlers to become established the Farm Security Administration has made available the use of heavy-duty bulldozers to enable them to clear their land at rates below those charged by commercial operators. Loans have also been made to permit the purchase of equipment for cooperative use. Without such aid the chances of making even a bare subsistence on much of what is definitely marginal land are poor.

Most farmers in these areas, as well as in other districts, whose holdings are inadequate are obliged to supplement their meager farm income by part-time or temporary employment in sawmills and other local industries. The hard-pressed newcomers are competing with both local and migratory labor for these types of work. Frequently the old-timers are displaced by the migrants, many of whom are superior workmen and willing to accept lower wages. Individual earnings have been reduced drastically, severe hardships have resulted, and widespread expenditure for relief has been necessary.

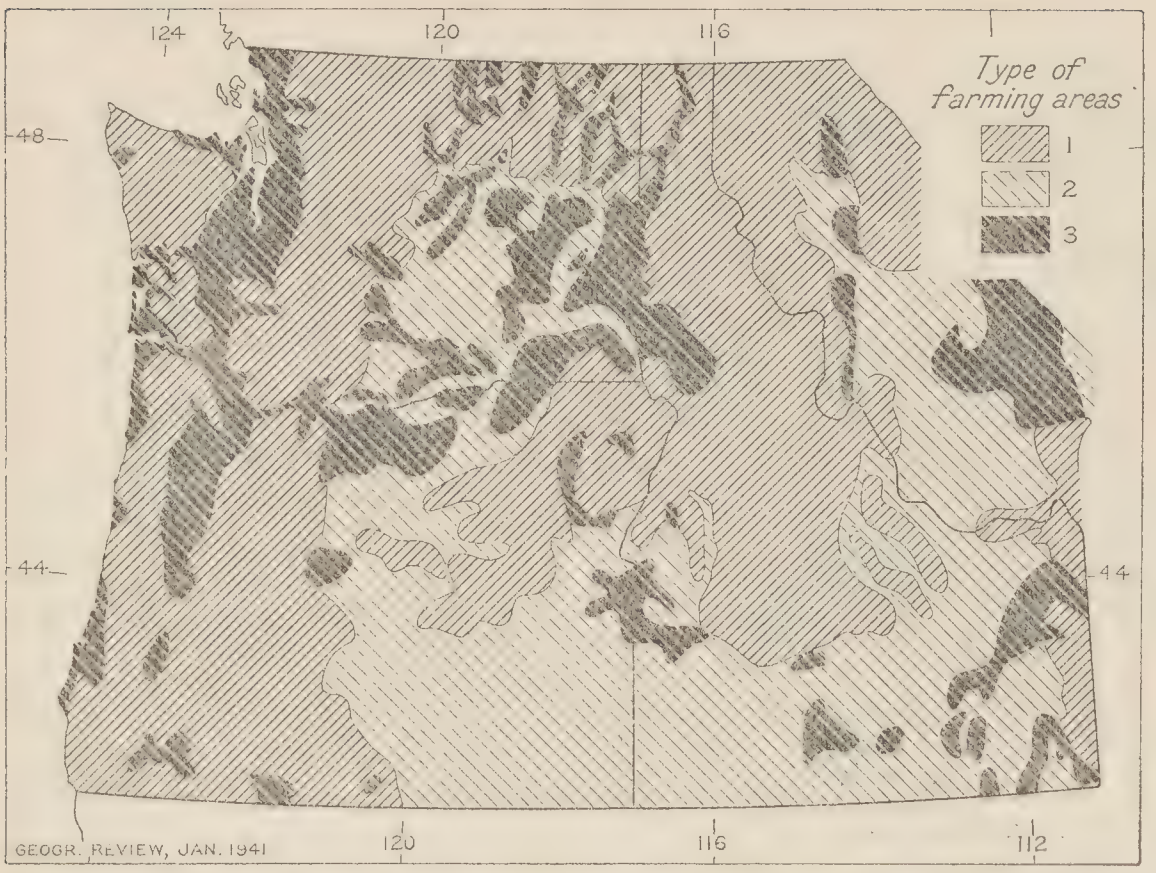


Fig. 7. Types of farming areas in the Pacific Northwest. Key: 1, mountainous and forested area, with limited grazing west of the Cascades (dense underbrush), fair to good grazing east of the Cascades; 2, open range with scattered irrigated and dry-farming areas; 3, agricultural areas. (Pacific Northwest Regional Planning Commission.)

In the remoter areas problems of resettlement are still more difficult; for example, in the intermountain valleys of western Montana, which have received a very heavy influx of people from the eastern part of the state and from the Dakotas. In an effort to facilitate rehabilitation in such areas of limited opportunity the Farm Security Administration has established an experimental project in Flathead County. About 300 families have been taken off W. P. A. projects, where they were earning $50 a month, and given a monthly grant of about $30 on condition that they devote full time to the clearing of their own land. In addition, loans of as much as $100 are made available for the purchase of blasting powder to be used in the removal of stumps. Plans are now under way for the establishment of a coöperative workshop in which handicrafts will be taught and small community industries developed.[6]

Similar problems have arisen in the urban areas. In the larger centers, such as Seattle, Tacoma, and Spokane, organized labor has opposed in most instances the admission of newcomers into the various unions, a prerequisite for employment in most of the skilled and semiskilled occupations. The industrial economy of the region is not able under existing conditions to absorb the additional labor available.

Social Problems.

All types of social problems have arisen. In general, the drought migrant is **persona non grata,** particularly if he and his family are a charge on the community. Low-cost housing facilities have not been available. Unsanitary "shacktowns" have grown up, both on the outskirts of the towns and in the open country. Many of these are a menace to the health not only of their residents but also of people in near-by communities. Medical services have been totally inadequate. School facilities in many parts have been taxed to the limit. Relief loads have increased beyond the capacity of communities to bear.

Agricultural Problems.

Agricultural land in the Pacific Northwest is limited. According to the best available information, only between 9 and 11 per cent of the region is actually and potentially arable (Fig. 7). Even in much of this small area intensive agriculture is practicable only where adequate water supplies are available; and, as a result of aridity, extensive rather than intensive land use obtains over much of the region.

More than 25 per cent of those gainfully employed in the Pacific Northwest depend on agriculture for their livelihood. In an area of 188,000,000 acres only 16,000,000 acres are cropped—8.4 per cent. Actually, the farm economy is based on only 10,000,000 acres, since

every year one-third of the cropland is in fallow or crops fail to mature because of drought. Most of this agricultural land has already reached the optimum degree of settlement. To increase the density of population in these areas would necessitate the provision of additional water to permit complete or supplemen al irrigation, extensive drainage, clearing, or some form of reclamation.

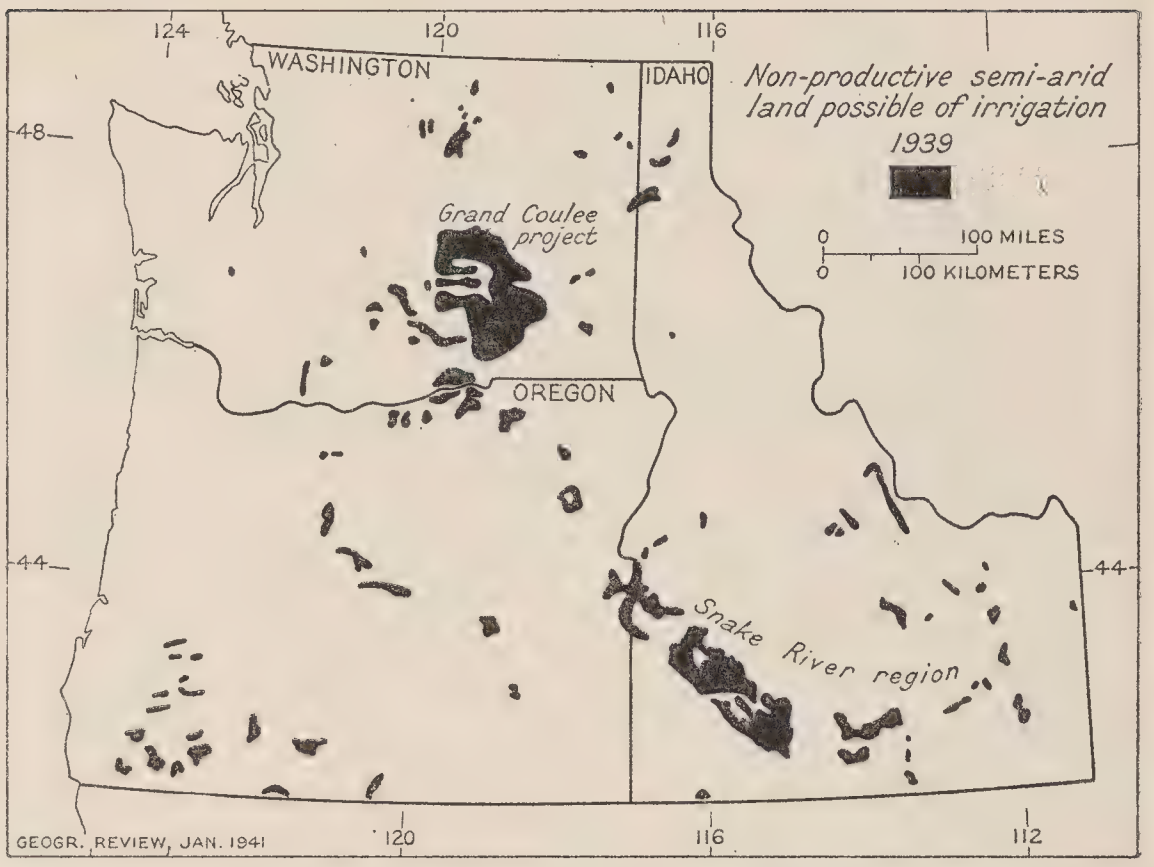


Fig. 8. Non-productive areas available for cultivation if irrigated. Certain areas in the Pacific Northwest, notably the Willamette Valley, need supplemental irrigation if effective land utilization is to be assured: these are not shown on the map. (Northwest Pacific Regional Planning Commission.)

It is estimated that, by irrigation, drainage, clearing, and diking, 5,000,000 acres of now unproductive land can be made available for cultivation, provided that soil-conservation practices are employed. But even this small addition involves expenses beyond the financial capacity of incoming settlers or of the individual states, for all land easy of reclamation is already occupied. Of this 5,000,000 acres, it may be possible to provide the water necessary to irrigate a total of 2,750,000 acres which are now inadequately supplied or for which water is not now available. Although small storage dams will permit the reclamation of a part of this acreage, most of it can be made productive only by the construuction of large dams with federal aid at strategic points on the Columbia-Snake River system. The Grand Coulee project will irrigate 1,200,000 acres and provide be'ween 15,000 and 25,000 new farms. Other projects under way or contemplated in the Snake River Plain will ultimately add another 1,000,000 dcres. By clearing brush, cutover, and timber, perhaps 1,000,000 acres can be made available. Approximately 250,000 acres need drainage, and additional small areas could be made productive through diking.[7]

However, the present area of crop land would not necessarily be increased by 5,000,000 acres. Some observers think that as much as 3,000,000 acres now under cultivation but unsuited to this type of use should be retired to permanent pasture. Hence the potential net increase in satisfactory cropland may not be more than 2,000,000 acres. To what extent the marginal land will be retired is a question that cannot be answered at this time. Economic conditions may change. It may not be entirely practical or desirable to retire suuch land in areas adjacent to large population centers, for example.

Reclamation is both slow and costly. It has been variously estimated that it will take from 20 to 50 years to complete the Grand Coulee project. Other estimates indicate that a maximum of 10,000 new irrigated farms can be made available by 1943, a total by no means adequate in view of existing demands. Moreover, the settlement of reclamation areas, such as the Grand Coulee project, will stimulate urban development and activities, which will in turn provide increased local as well as regional employment opportunities.

Irrigation agriculture is expensive.

Fig. 9.

Fig. 10.

Fig. 9. Home of a settler (on F. S. A. loan) in Boundary County, Ida. October. 1939. (Photograph by Dorothea Lange for F. S. A.)

Fig. 10. A farmstead in Malheur County, Ore. October, 1939. Note the siphon which brings irrigation water from the opposite bench. (Photo by Dorothea Lange for F. S. A.)

Fig. 11.

Fig. 12.

Fig. 11. A new farm (F. S. A. loan) on cut-over land in Bonner County, Ida. October, 1939. (Photo by Dorothea Lange for F. S. A.)

Fig. 12. Newly reclaimed bench land in Malheur County, Ore. October, 1939. This farm was "taken out of the bush" three years ago. (Photo by Dorothea Lange, for F. S. A.)

Fig. 13. In the wheat country of Klickitat County, Wash. Abandoned farm in foreground; occupied farm beyond. August, 1939. (Photo by Dorothea Lange for F. S. A.)

Fig. 14. "Raw land" in Malheur County, Ore. October, 1939. (Photo by Dorothea Lange for F. S. A.)

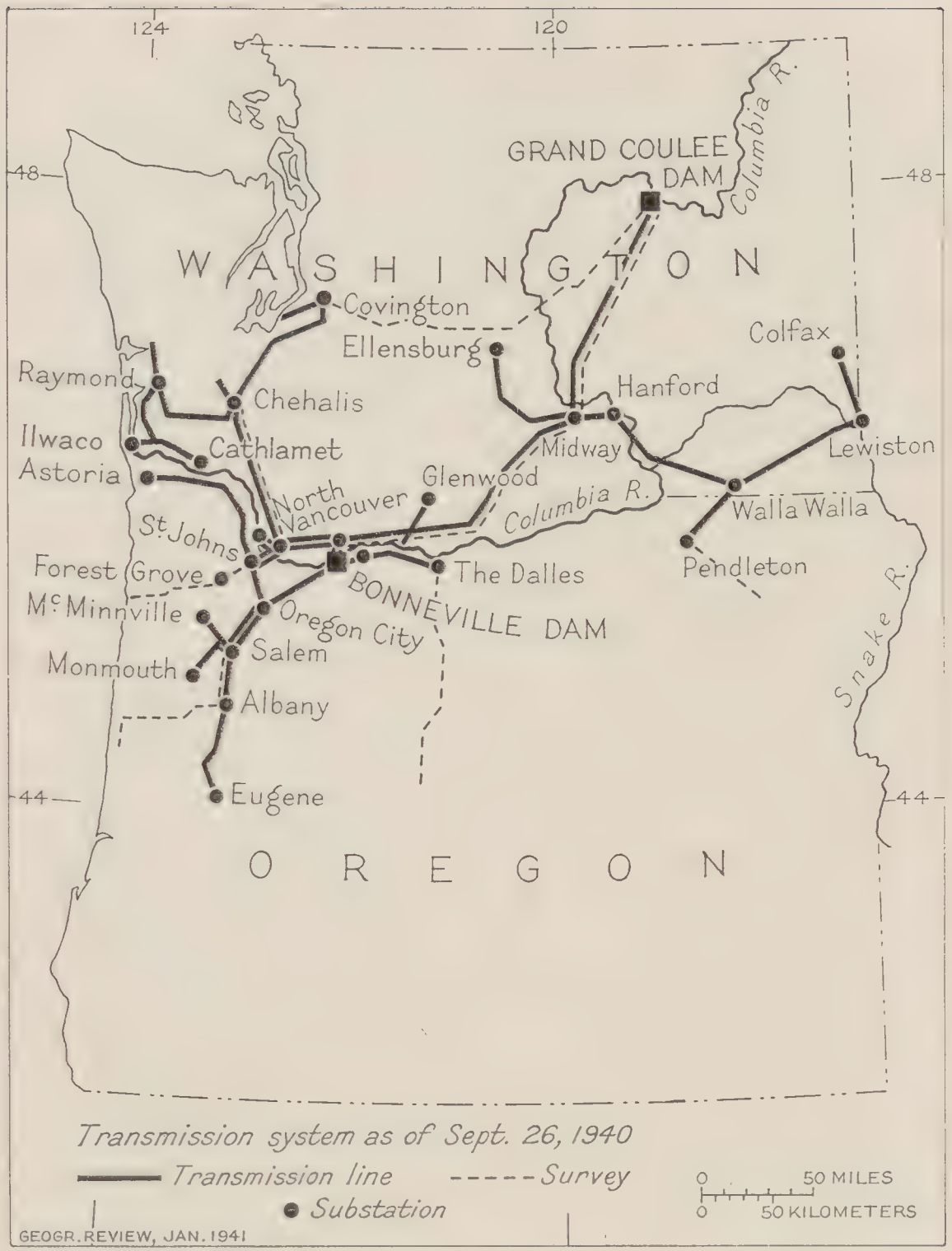


Fig. 15. Bonneville super-power network, September, 1940. (Bonneville Power Administration, Portland, Ore.)

Figs. 16 and 17. Aerial photographs of the Grand Coulee Dam in construction. (Grand Coulee Administration.)

At $5 to $15 an acre the average 80-acre farm of this type costs about $800. To this amount must be added the charge for providing irrigation facilities. This represents a large investment even when the costs are spread over a period of 40 years. Some form of aid is essential if any but adequately financed are to take up these lands as they are made available. As a means of meeting the situation, the Farm Security Administration is providing assistance to approved applicants by granting loans for one, three, or five years at 5 per cent to individuals and 3 per cent to coöperatives and by developing mechanized techniques for clearing and preparing land expeditiously at costs much lower than were previously possible.[8] Recently 10-year loans have been considered; but few, if any, such loans have yet been made. Efforts are being made by other federal agencies to work out comprehensive presettlement land-use plans for newly developed irrigation areas such as the Grand Coulee project. This should prevent costly initial mistakes on the part of settlers lacking experience in this type of agriculture.

The provision of water facilities is only one phase of the reclamation of semiarid and desert land. Irrigation agriculture involves techniques and crop systems that must be adapted to soil and climatic conditions with which most migrants from the Great Plains are unfamiliar; and technical advice, based on the result of scientific surveys, is essential during the first few years of occupation.

As more new lands are opened up, the marketing problem increases. Numerous cases have already occurred in which the balance of supply and demand in isolated irrigated areas has been upset because new acreage has come into production. In the Vale-Owyhee area the increased output of hay that followed the opening up of new land there exceeded the demands of the local cattle and sheep industry, to which agriculture in the area had previously been adjusted satisfactorily. This changed situation necessitated a shift from hay as the cash crop to a more diversified type of farming in which potatoes, sugar beets, onions, and seed crops are becoming increasingly important. At the same time, the number of livestock has been gradually increased. When additional land is brought into cultivation, any land-settlement scheme designed to meet the needs of the surplus rural population must involve measures to ensure the adjustment of production to available markets while additional commercial outlets are being developed.

Present agricultural opportunities are totally inadequated to provide for urgent needs, and what expansion is possible will take considerable time. Consequently, other outlets for the present surplus population must be found. Many believe that through the expansion of existing industry and the development of hitherto untapped industrial resources economic opportunity throughout the region can be most effectively expanded.

Induustrial development in the Pacific Northwest has not kept pace with the increase in population during the past several decades. This retarded development is due in part to limited local markets, distance from populous eastern markets, high freight rates, and external financial and economic controls. The present economy is based chiefly on the exploitation of primary products such as lumber, agricultural crops, wool, hides, and metals, which are largely processed outside the region. The per capita value of new wealth created in the region in all industries except those concerned with foodstuffs, lumber, paper, and allied produucts is far below the national average. Of the total number of wage earners employed in factories, more than 62 per cent are dependent direectly on forest industries and 16 per cent on food processing. Thus 78 per cent of all wage earners employed in manufac-

turing belong to these two groups. This unbalanced industrial pattern is reflected in the commerce of the region.

Forest Products and Industries.

In 1929 forest products contributed 41 per cent of the value of exports, agricultuure 24 per cent, livestock 17 per cent, and manufactures only 15 per cent. In the same year manufactured goods made up 77 per cent of the value of imports.[9]

A rapid and considerable expansion of industries based on regional resources seems to be both desirable and practicable. Such a development would take up some of the slack in employment and ensure greater utilization of the industrial possibilities of the region. It would involve the expansion or stabilization, wherever possible, of existing industries, the development of new techniques for converting industrial wastes into useful by-products, the establishment of new industries based on regional materials now processed elsewhere, and the utilization of resources hitherto untouched.

Forest lands comprise 36 per cent of the total area of the Pacific Northwest and contain 48 per cent of the remaining saw timber of the United States. Lumber constitutes 63 per cent of the railroad tonnage originating in the region and 87 per cent of the inland water tonnage. The vast output of rough lumber, most of which is exported in that form, offers a wide field for the expansion of existing fabricating industries such as pulp and paper, furniture, and specialty building materials. New industries, utilizing wood wastes and low-grade lumber to produce rayon, cellulose, lignin, and other chemical products on a large scale, are undoubtedly feasible. Development along these lines would stimulate as well as stabilize employment throughout the forest and lumber industries in addition to providing new employment opportunities.

The preparation and processing of specialty food products have made considerable headway in recent years. The market for such products—quick-frozen fruits and vegetables, for example, for which the Northwest has won well deserved acclaim—has been scarcely touched. Considerable expansion in production is possible. Little so far has been done to utilize surplus farm crops for the manufacture of industrial products. Chemurgy offers a promising outlet for both agriculture and labor.

Mineral Resources and Industries.

Mineral industries, which hitherto have largely produced metals for shipment in crude form for fabrication elsewhere, now show promise of early expansion. The region is said to possess a wide variety of resources, but except for metals little use has been made of them. Although mineral production ranks third in the economy of the region as a whole, in some parts, particularly in Montana and Idaho, metals are a chief source of income. At present silver, mercury, copper, gold, and zinc are the principal metals mined; but large quantities of iron ore, magnesite, tungsten, chromite, and antimony exist. Improved technology in mineral extraction and metallurgical processes, increasing demands for lighter structural metals such as aluminum and magnesium, and abundant low-cost hydroelectric power may make it possible to exploit low-grade deposits for local industries.[10]

Nonmetallic resources are diverse and widely distributed, but their extent and quality have not been accurately appraised. There seems to be a large amount of coal in the region, but inferior grades predominate, though some high-grade coking coal and anthracite do exist. The principal deposits extend along the flanks of the Cascade and Coast Ranges, relatively accessible from tidewater and centers of population. Folding and faulting have been extensive throughout the region, and many of the coal seams dip steeply, thus adding materially to the cost of mining. Extensive phosphate beds, the largest reserve of its kind in the whole country, occur in southeastern Idaho

and adjacent areas of Montana, Wyoming, and Utah. There has been very little production despite the urgent need for the use of commercial fertilizers in the region. Considerable deposits of fire clays, limestone, building material, sands, kaolin, and pumice exist.

Industrial expansion based on these local mineral resources has become a real possibility with the advent of Columbia River hydroelectric power. With 41 per cent of the total potential water power of the United States, the Pacific Northwest possesses an important industrial asset. The great multipurpose dams at Bonneville and Grand Coulee will increase present power facilities by 3,350,000 horsepower, part of which will be available in large blocks for industrial uses anywhere in the region. Plants are nod under construction for aluminum and iron industries near Vancouver, Wash. Cheap electric power is a main factor in determining their establishment in the region. The trend seems to be definitely in the direction of not only increased mining activities but also, what is equally important, the development of a variety of fabricating industries to supply the regional market. The power-transmission grid will permit decentralized industry, since a uniform rate prevails throughout the area served.

Similar developments in electrochemical and electrometallurgical industries may be expected. It is equally feasible that important industries based on local, regional, or even imported raw materials may develop, provided electric power is cheap enough to offset regional handicaps imposed by limited markets, freight charges, and other economic factors.[11]

Side by side with these developments a wide variety of subsidiary and service industries designed to supply the needs of the new or expanded major industries would grow up, and thus the economic base of the region would be still further broadened.

This expanding industrial pattern, provided national development is encouraged, will do much to solve the employment problem, to stimulate agriculture and other extractive industries, to promote economic security and increase economic opportunity, and to facilitate the assimilation of newcomers to the region, who, in the long run, will prove to be an advantage rather than a handicap.

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The Relation of Engineering to Soil Conservation Programs

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Conservation in this country has differed in many respects from that in other countries, primarily due to our cherished custom known as Freedom. This so-called freedom, together with the lack of common sense in many farming practices, has brought about losses in our agricultural resources. The present unfortunate conditions could largely have been avoided by educating the farmers in regard to the need and suggesting methods to carry out a well rounded program in conservation.

There have been many changes in the flora and fauna in this country which were brought about in the development of these United States. The big problem before us now is to build back the ecological requirements which have been disturbed by our agricultural and forestry cropping.

The old world has many practices which are correct, some of which could be adopted by us; but care must be taken, since our topography, climatic conditions, and environment may differ from those in other regions. The same may be said of the several regions in this country, but the experiences of one locality are not used by another to the fullest possible extent.

The need for education is still evident in conservation. Demonstrations are likewise very essential, and especially those that are most successful. The place where these are most needed is without doubt on the land where man is in the best position to aid in bringing about such changes as are necessary.

The job of the engineer is to apply sound engineering principles and practices to this program of conservation. The structures for the individual farm or group of farms, require the same fundamentals of hydraulics, mathematics, physics, mechanics and other sciences as in the larger and more intricate reclamation projects. The engineer in this field must also have a good agricultural background, with proper training in soils, agronomy, farm management, and forestry if he is to be a success and of the greatest value to the organization. Many engineers without the proper training in agricultural subjects tend to limit their vision of specific problems to the immediate details of hydraulic and mathematical formulas and overlook the ultimate result and proper application of engineering in agriculture. The engineer then must be able to contribute into a pattern of which he is but one of the designers. Close cooperation with the other specialists is most essential.

There are many methods used for the control and conservation of our land resources. The field is so large that it will be necessary to consider but a few of the many. There are certain fundamental methods used in the control of cultivated land which should be fully appreciated as they must be analyzed by the engineer to more readily determine what he must do to accomplish the desired end. These methods are:

1. To intercept, divert or store the surface runoff.
2. To improve the structural characteristics of the soil.
3. To bind the soil in place through the use of vegetation.

These three methods, if properly coordinated by the engineer, will largely control the soil losses brought about by water and wind, and will result in the conservation of water in our arid and semi-arid regions.

The first method mentioned,—namely, to intercept, divert or store the surface run-off,—is the engineer's chief problem. In one part of the country it is important to conserve and store the water, while in other areas it must be led off the slopes in such a manner as to avoid damage to the soil by washing.

Proper and adequate disposal of the surface run-off is the major problem in the development of a satisfactory conservation plan. It is poor planning to expend funds and effort in securing proper land use and at the same time to neglect the drainageways which must convey the concentrated run-off. Gullying will occur and in many instances has quickly taken place in the neglected drainageways.

Mechanical structures provide effective control of run-off water, but the high cost of installation restricts their use in most cases to areas where erosion-resisting grasses cannot be grown. The use of mechanical structures has some distinct advantages over a grass outlet ditch on areas where land values are high. Less space is needed for the outlet channel, and it is ready for use as soon as the concrete is set. In many areas a type of grass may not be available, or the grass may be too aggressive for use in drainageways occurring in cultivated fields. The mechanical structure can serve in such instances as active overfalls may be eliminated and land which has already been destroyed through erosion can be utilized as a drainageway.

Oklahoma has done some experimental work in the casting of concrete slabs on the ground and, after they are set, using them to construct baffles in the drainageways that are eroding. This method costs less than masonry or monolithic concrete and can be installed with a small amount of labor.

The engineer has taken advantage of the work done by the agronomists in developing grasses for erosion control and is using the sod in the construction of sod dams. These are being used in the semi-arid as well as the arid regions of the United States. The dam is constructed across the small gullies with dirt, leaving a weir section in the center. The dam is then covered with sod. The sod serves as a mat over which the water flows.

The method of diverting the water out of a channel while some erosion-resisting grass is being established and then turning the water back into that channel after it has been stabilized has been practiced to a large extent, with considerable success.

An effort has also been made to construct temporary structures for gully control, with the idea in mind that grasses would eventually take over. This practice has not met with success, and the value of it has not been proven. The tendency now is not to use it as a generally recommended practice.

The concentration of water flowing down a slope produces erosion. The engineer, in his plan to shorten the surface run and prevent the increase in volume of flow suggests the use of terraces or diversion ditches to intercept this flow. The water is led to natural streams or prepared drainageways at non-erosive velocities.

He has used vegetated outlets and met with some success but again sufficient data was not avaiable for him to properly evaluate it and determine the limits of adaptability as an engineering material of construction. There are certain things he must know such as durability, dependability, behavior under water loading conditions that are needed for sufficient growth and time required for such growth to be attained. As this was not all recorded for his use, experimental layouts were set up. It was readily demonstrated silting would take place in these outlets along with scouring. The present trend is away from vegetated channels and toward one of the meadow strip design. This allows the spreading of the water over a larger area, use of the water to promote growth, gives some return in the form of hay and encourages maintenance work by the cooperator. The encouragement of proper maintenance work and educating the public of the need for such is, in itself, a problem.

In a recent survey made by the Soil Conservation Service in the Middle West, it was found that more failures

in the various methods used in conservation practices were due to the lack of proper maintenance work and the failure of the cooperator to realize the necessity for it, than any other one factor.

In the construction of diversions and diversion terraces, the silting in of the channels was found to be a factor of considerable importance. Here the engineer has adapted the use of a grass strip above the channel of sufficient width to filter out the silt from the surface water before it enters the channel. Here again more work needs to be done on breeding or finding a selection of grasses that will successfully withstand this silting. It also requires more work on the prevention of the concentration of water through the filter due to the dropping of the silt as the water strikes the strip and building up a dike.

The scientific answer to many questions must await the results of additional years of research, but as time passes the problems have and will continue to shape themselves into such a form as to present some clear features.

Terracing has withstood the test of time, having been used in Biblical times; but we are in need of better coordination of principles and less rule-of-thumb practices. Carelessness and ignorance exercised when making a terrace layout has brought about many failures avoidable through more research and knowledge of the factors determining the extent of run-off.

The resistance to dislodgement of individual soil particles is of importance in conservation. This dislodgement is depending upon dispersivity, moisture equivalent, and colloid content. The porosity and friability under normal cropping practices are insufficient to absorb the rain as it falls so surface run-off is bound to follow. This run-off causes the soil loss and the amount is a function of the characteristics just mentioned. Here may lie the answer to many difficulties encountered in the spacing of terraces.

In the pastures considerable work has been done on the construction of contour furrows for moisture conservation. In a recent survey made on a series of farms, the vegetation was much improved in the furrow and for a short distance below the furrow. This survey would point toward the closing up of the space between the furrows thus bringing about a better distribution of the water.

Some interesting work was carried on by Professor J. H. Neal of the Department of Agricultural Engineering of the University of Minnesota on the effect of degree of slope and rainfall characteristics on run-off and soil erosion in which he made the following conclusions. Infiltration was not affected by either slope or the rainfall intensity, but varied inversely as the initial soil moisture content. Percentage of slope had no apparent effect on the percentage of run-off for slopes above one per cent. Percentages of run-off increased as the rain intensity increased, but at a decreasing rate. When the soil was dry before a rain, run-off did not occur until several minutes after the rain started. The time elapsing between the beginning of the rain and the time when run-off occurred decreased as both the slope and the rain intensity increased. After run-off started there was a continual increase in the rate until the infiltration rate had become approximately constant. This occurred 1 to 2 hours after the beginning of the rain.

Density of the run-off material decreased during the first hour of rain. When the rain continued longer, the density remained approximately constant.

From 1½ to 2 times as much run-off was required to remove a pound of soil at the end of one hour as at the beginning of the rain.

Relative density of the run-off material increased as both the slope and the rainfall intensity increased.

Soil losses from a saturated soil increase as the .7 power of the slope, the

2.2 power of the rain intensity and directly as the time of duration of the rain.

The amount of erosion from a soil which was in a dry condition at the beginning of the rain was affected by the initial soil moisture content and the condition of the soil surface, in addition to the degree of slope, the rain intensity and the duration of the rain.

A soil in a dry, pulverized condition or one in a dry, rough condition will absorb much more rainfall than one in a smooth, hard, packed condition.

It is research of this nature combined with that found in other fields which is needed to remove the uncertainties in conservation engineering.

The use of vegetation to bind the soil in place and retard surface flow is used by the agronomist and forester in controlling water and wind erosion. As mentioned earlier in this paper, the engineer finds use for it in developing drainageways and serving as a filter above diversion terraces and ditches. He likewise finds use for grasses, vines, and shrubs in the prevention of erosion in cut and fill slopes on highways, gully banks, earth dams, and to stabilize spillways sections of low dams serving small drainage areas.

The agronomist and forester supply the directions for the adaptation and growth of the vegetation but the engineers has contributed materially in improving methods of transplanting and the reshaping and preparation of cross sections to ensure more successful plant growth.

The improvement of the physical condition of the soil is of value to the engineer since he is interested in the ability of the soil to hold water. Through the use of legumes, crop rotations, liming and others the absorption and the quantity of rainfall storage can be increased. The engineer can contribute to this item through the use of machinery to break up the tight subsurface, and improve tillage practices. This will all help him in reducing the run-off and increase protection to any structural measures.

I have mentioned only a few of the many contributions the engineer has made and can make in the field of conservation.

His importance in this field can perhaps best be illustrated in the number employed by theSoil Conservation Service as of November, 1940, in comparison to those in other professions. The number is as follows: Agronomists, 646; Soils Men, 690; Foresters, 301; Engineers, 1227; Soil Conservations, 1635. Engineers also comprise a part of the number classified as soil conservationists.

The engineer must at all times be alert to the interrelation between the technical and human problems involved in his work. He must contribute his share to the field of conservation comprised of all branches of agriculture. That contribution must be along the agricultural phase as well as the engineering, or he will slowly pass from the picture.

1941 Meeting

Dates for the 1941 meeting of the Northwest Scientific Association are December 29 and 30 at the Davenport Hotel in Spokane.

Forest Facilities Vital for National Defense Purposes

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As we read in our daily newspapers of the progress our nation is making in the marshalling of its man power, industrial, physical and national resources we wonder if there is any single thing which does not have its place in an "all-out" defense program. Why can't national defense be simple as in the days of Attila, Alexander or the Caesars? Then the Knight buckled on his armor, donned a visored helmet, strapped his sword to his waist, mounted his charger and rode to combat. Footmen followed with cross bows, battle axes and lances. History tells us that warriors took leave of their families and were gone for years on end. Transportation and communication as it is known today was non-existent. Once an army or legion had departed on its campaign the populace settled down to its normal routine. At least looking back casually through the years that is the way conditions seemed.

But that picture is an illusion created by the passage of time. We have a fairly good record of the Punic wars which occurred before the year 200 B. C. between Rome and Carthage. The Romans had to build over four hundred ships to carry their men over the Mediterranean. Timber had to be secured from the forests and skilled workmen—carpenters, metal workers, shipfitters—had to be trained before the keels could be laid. Materials and subsistence had to be gathered to outfit and feed several hundreds of thousands of men—no easy task in those days of great distances. Hannibal had to provide for his herds of elephants used to break the ranks of the enemy in those days, collect his hordes of Numidian horsemen, his Balearic slingers and contingents of men and supplies from dozens of different tribes. Where a single telephone line now serves the purpose, it required hundreds of messengers then to equal the same service. Then before embarking on his campaign he had to defend himself from political usurpers biding their time to secure possession of the country during his absence. He solved this problem by garrisoning Carthage with Spanish soldiers and Spain with African troops feeling that the foreign soldiery would be less amenable to local politicians.

So in those days, too, every one had his job to do. Every individual in this room undoubtedly has a fairly clear conception of the niche he occupies in the present emergency. As it is with individuals so it is with national, state, or private organizations. Each group is given its task in the master or "M" plan as we hear of it. The Forest Service is no exception and it is my purpose to give you some understanding of what facilities the Forest Service possesses that can play an important part in national defense.

The speakers before me have outlined the invaluable uses of wood for war purposes for housing, gunstocks, explosives, wood chemicals, gas masks, plastics, airplanes, or hundreds of other uses. First of all it is the job of the national, state and private forest organizations to protect our forests to insure a steady supply of raw materials. The guarding of those raw materials from loss by fire is unquestionably a major defense problem. But aside from fire protection the physical facilities possessed by forest administrative organizations can be utilized to such an extent by a military command that it is with that thought in mind the forest facilities have been enumerated and described.

1. AVIATION

A. Landing Fields.

The Forest Service now has approximately 3200 lookout houses and towers located in a checker board fashion over

the national forests. Under the direction of the Civil Aeronautics authority the roofs could be painted and numbered—a job which has been completed in Region 1—which would be of great assistance to aviators in cross country flight. They could also serve as listening posts for approaching aircraft.

There are eighty landing fields in existence. Many are small and unimproved and are unable to accommodate the larger planes. However, a large proportion could be improved and put in shape for almost any type of aircraft without a very great expenditure. The location of these fields in mountainous country does have the additional value of offering at least emergency landing space in areas far removed from regular air bases.

Another unique value that some of the Service fields offer is that of combat and bomber plane storage. With high parallel mountain ranges ideally located for the placement of anti-aircraft guns it would be almost impossible for an invading aerial squadron to destroy the planes on the ground as so often has been the case in the present war.

B. Aerial Photography.

Aerial surveys have been conducted by the Forest Service during the last several years. Over 130,000 square miles have been photographed of which over 80,000 square miles have been converted into maps. No o her detailed surveys of this territory exist.

In the Pacific Northwest and California the Service has developed, in connection with fire scouting, methods and technique of taking photographs from the air, developing them in the plane, and delivering prints to forces on the ground all in a period of eight minutes. These methods have been inspected with interest by military authorities and, of course, can be made available to them.

C. Aerial Dropping of Supplies.

Many of the forest fires which occur on national forests occur in the back country far from any means of transportation. The problem of dispatching and delivering of men, supplies and equipment to these remote areas has been a Gordian knot to fire protection men. If a goodly number of the fires occurring in these remote areas were to be manned and the firefighters supplied and equipped by the conventional methods of pack horse or back pack transportation it would take several days to even make a start on control thereby greatly increasing the final cost of suppression and damages.

In an effort to cut down this first attack time, about four years ago the Forest Service began experimenting with the dropping of supplies and equipment on fires. Previous to this time there had been little or no experimenting with the dropping of supplies from airplanes. The Service, therefore, had to start from scratch. Dozens of methods were tried, all more or less revolving around four general principles:

1. The loose pack method—in which a small quantity of supplies is discharged in loosely tied gunny sacks.
2. The tight pack method—in which the supplies are wrapped in excelsior and heavily roped canvas.
3. Bundles wrapped in canvas and dropped with a retarding wool burlap sack chute.
4. Bundles lowered by a conventional chute.

At the present time dropping technique has reached a point where it is possible to drop cross-cut saws, radios, hot meals or eggs with almost no breakage. The hot meal by the way consists of roast beef. mashed potatoes, gravy, fruit, sliced fruit cake, coffee and ice water.

While the figures are not as yet available some idea of the importance of the dropping facilities available and of perfected techniques can be gained by a review of Region I's record during the 1940 season. Over 400,000 pounds of fire equipment were moved, of which 148½ tons were dropped on fires. A

good share of this tonnage was delivered to fire fighters at a greater distance than the Germans supplied their forces at Narvik. Crews of a maximum of 400 men were fed by air transportation alone. Think what that would mean to an army in wartime, operating in mountainous and inaccessible country—perhaps similar to the terrain in which Greek and Italian forces are struggling in Albania at the present time. Military authorities have detailed men to inspect Forest Service equipment and analyze methods employed, all of which are available to them.

D. "Smoke Jumpers."

Last year the Forest Service commenced experimenting with the dropping of parachutists or "smoke jumpers", as they have become nicknamed, on fires in rough mountainous terrain. The difficulties confronting those in charge of the experiments seemed insurmountable at the start. The parachuting of men in precipitous mountain areas in a civilian pursuit was a revolutionary idea that seemed the product of day-dreamers. But with "Safety to the man" as a criterion the "Day Dreamers" persisted. Out of the experiments has evolved a technique which presents a distinct contribution in aerial warfare to those in charge of our national defenses.

Aside from the military use to which this development can be put it offers a unique method of apprehending saboteurs in any inaccessible place. In the event of an incendiarist operating in any certain area "smoke-jumpers" could be dropped at strategic points to block avenues of escape and then if he should be observed from the plane patrol he could be literally pounced upon from the air.

In peace time incendiarists in our forests do not constitute the major problem of fire protection. But in wartime, if we can judge by what is happening in Europe today, it is going to be a nightmare to forest administrators in the fire season. A modern bomber can carry thousands of incendiary bombs in a single load. What would happen to our forests if a bomber or two scattered its load in the middle of August? The average forest can handle from fifty to a hundred lightning fires set in a single day but that is a somewhat different problem. The "smokejumper" may be the answer for a speedy decisive attack on the various sets. If the national, state, and private protection agencies aren't able to handle the situation it is entirely conceivable that the smoke pall which will result will so reduce visibility that military planes in many sections of the country will be immobilized.

A further result of such an attack might be the necessity of diverting hundreds of thousands of men to fire fighting from other needed defense projects at a time when they could least be spared.

E. Communication.

A network of over 63,000 miles of telephone lines now furnishes communication on the forests covering remote areas where commercial lines are nonexistent. These could be of vital military importance.

In addition the Forest Service has in operation 3,000 radiophones of the portable type. They have already participated in military air games. Extensive maintenance facilities for both telephone and radio communication are a part of Forest Service equipment.

F. Roads and Trails.

Transportation routes have been extensively developed within the national forests. A summary of these facilities is as follows:

1. Forest highways—23,500 miles. These highways are comparable to first class State highways.

2. Development of roads—83,900 miles, commonly called truck trails. These roads are narrow but safe for a maximum of 35 miles per hour.

3. Foot and horse trails—137,000 miles.

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All roads and trails were designed and constructed by Forest Service personnel to meet the peculiar needs of transporting timber products, supplies, and materials incident to the development and everyday administration of the forest resources.

The tools and mechanized equipment used in similar construction and in operating condition now owned by the Forest Service would represent an extremely vital factor in solving transportation problems faced by a modern army. Such machinery is equally adaptable for the extension of present roads, construction of army bases or airports. As an indication of the quantities of such material on hand, Region I alone could furnish over 100 bulldozers. Incidentally the bulldozer, the almost indispensable tool of road builders, is a Forest Service engineer's invention.

The fleets of trucks now in use in carrying on every day business if commandeered by the military authorities could move tens of thousands of troops in a matter of hours. If comparisons are in order, the trucks of the Forest Service would make the transportation furnished by General Gallienne to his taxicab army out of Paris in 1917 look like small potatoes indeed.

An additional means of transportation has not received a great deal of publicity. The National Forests in Alaska include many islands and thousands of miles of coast line. Forest officers perform their every day duties in a well equipped fleet of boats and could render invaluable service in the patrol of our coast line keeping a lookout for suspicious activities and in assisting in the selection of locations for defense installations on or near coast lines.

And, last but not least, thousands of fully equipped pack animals are available for transportation of supplies and materials in roadless areas. Pack strings carrying 200 lbs. per mule load per day can move a tremendous amount of supplies.

G. Maps.

One of the paramount needs of military men is accurate maps. Every national forest has been mapped and maps of ¼", ½" and 4" scales are available. These maps are accurate and give in detail physical improvements on the ground in addition to locations of bench marks, triangulation points, and general planometric survey data. In many cases they give topographic data as well. Relief models and relief maps have been made of certain areas.

2. TRAINING FACILITIES

A national defense program of the magnitude of our present program calls for technicians and skilled craftsmen by the tens of thousands. Mechanization is the order of the day and the more mobile military forces become the greater is the demand for mechanics.

Of necessity the Forest Service has had to train personnel to care for its own equipment. It has had to establish and equip shops to maintain the equipment. Those same shops scattered on every forest ranger district, and in every one of the 619 CCC camps in national forests offer the most ideal facilities for training mecnanics and technicians in a variety of mechanical skills.

No doubt there are many other facilities that the Forest Service possesses which could become invaluable in the defense program; as for instance, the every day equipment used in feeding and caring for the physical needs of fire fighters. It was possible for the central service of supply unit here in Spokane last summer to put equipment at points as far away as five hundred miles in sufficient quantities to care for 17,000 men within 48 hours. Those of you who are familiar with the details and difficulties of organizing, assembling, and dispatching equipment in such quantities know that the performance of that job deserves commendation.

Time alone can tell to what extent the National Defense Board will draw on the facilities of forest operators, the State, and U. S. Forest Service.

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Publications of the Northwest Regional Council

THE PACIFIC NORTHWEST: A Selected Bibliography. Northwest Regional Council, 0606 Bedell Bldg., Portland, Oregon, 1939. Price $3.00.

This 456 page book is a valuable publication on available material along geographic lines in the Northwest. It lists by authors nearly 4,000 titles of articles on the Pacific Northwest that have appeared during the years 1930-1939, and over 650 other topics on which research is in progress or which is contemplated. The bibliography is usable and well organized. Archaeology, climate, forests, vegetation, agriculture, history, geology, mineral resources, physiography, water resources, maps, reclamations, commerce and industry, recreation, wild life, government, regional planning, economic surveys and other bibliographies are among the topics discussed.

The publications will prove invaluable to anyone doing research on the Northwest, and libraries and institutions should add a copy to their collections for reference. The type is large and readable, the pages are 7½x10½ inches in size and short summaries of the article follow many of the references. Several sections are preceded by an introduction by an authority on the subject. The reviewer heartily congratulates the Northwest Regional Council on the general excellence, attractiveness, and usefulness of this publication.

Other informative publications of the Northwest Regional Council include:

Forest Depletion in Outline, 1940. Price 25 cents.

Soil Conservation in Outline, 1940. Price 25 cents.

Pacific Northwest Resources in Outline, 1940. Price 25 cents.

Pacific Northwest Problems and Materials, 1940. Price 25 cents.

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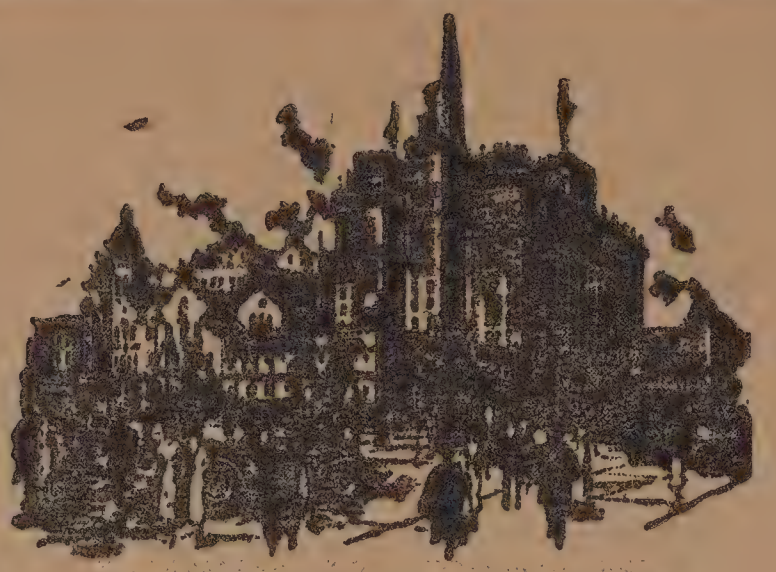

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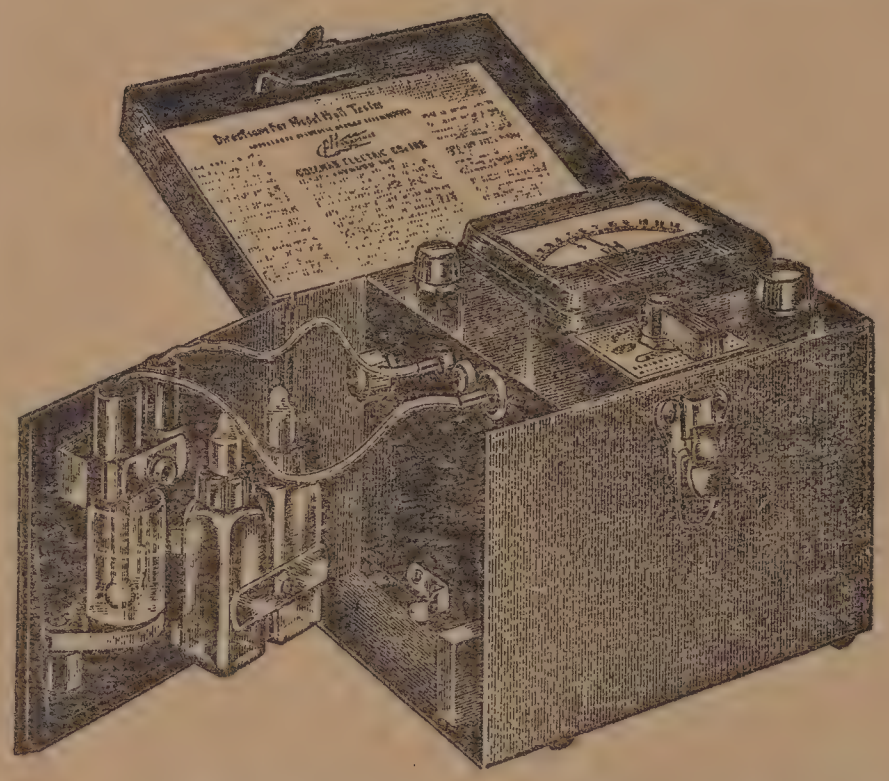

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MEETINGS PACIFIC DIVISION A. A. A. S.

The meetings of the Pacific Division of the A. A. A. S. and affiliated societies will be held in Pasadena, June 16-21, under the auspices of the California Institute of Technology. The Northwest Scientific Association is one of the affiliated organizations and its members are cordially invited to attend the meetings. Scientists wishing to present papers should write Secretary, Pacific Division, A. A. A. S., Stanford University, California.

The Role of Research in Regional Development

JOHN B. APPLETON
Northwest Regional Council, Portland, Oregon

The highest economic and social well being of which a region is physically capable should be the goal in regional development. This can be achieved only through (1) the effective use of all available resources, physical as well as human, (2) a logical development that will be of permanent rather than transitory benefit to the people of the region, (3) the elimination of wasteful exploitation likely to result in social and economic dislocation and disintegration, and (4) the development of sound public policies to deal with regional affairs. Research and the effective use of its findings provide a scientific method by which this goal can be reached.

The role of research in regional development includes: (1) the collection and interpretation of the necessary data, both physical and economic, which will insure a thorough understanding of the regional environment and of environmental relationships; (2) the discovery and application of improved or new techniques which will provide the basis for desirable readjustments and increased economic opportunity; (3) the dissemination of accurate information in ways that will assure public understanding of the salient facts concerning the region and of the problems confronting it, of its opportunities and limitations, of necessary readjustments that should be made to increase economic wellbeing, and of the need for cooperative effort in the formulation of action programs to implement desirable administrative policies.

A few pertinent examples drawn from the Northwest will illustrate these prin-

ciples. Land is the basis of human existence, for from it man derives the comforts and necessities of life. In the Pacific Northwest, agriculture is one of the two major occupations since approximately 24% of those gainfully employed depend directly or indirectly upon agriculture and the associated industries. In an area of 188,000,000 acres, only 16,00,000 are tilled, 8.4% of the whole region. Actually, the farm economy is based upon 10,000,000 acres because every year one-third of the crop land is either in fallow or crops fail to mature in consequence of drought. The effectiveness with which this small area is used and the degree to which its productivity is maintained are of vital significance to the economy of the region. Unfortunately, unsatisfactory methods of tillage, improper cropping, failure to maintain fertility by the application of fertilizers or the cultivation of soil-building crops, inadequate soil erosion control measures, are reducing the productive capacity of the land materially. Every one of these problems calls for intensive research, research which takes into account not only local physical conditions but the closely related economic and social factors which contribute to soil misuse.

The influx of farmers from the drought areas of the northern Great Plains has created a serious land problem in the Pacific Northwest since the amount of farm land is not adequate. During the past two decades the acreage of crop land has not increased in proportion to the change in population. Rugged terrain and arid or semi-arid conditions definitely restrict the area of cultivable land. By irrigation, drainage, and clearing it may be possible to add 5,000,000 acres to the present crop area. Where and how this reclamation can best be accomplished necessitates intensive research. Of this potential farm land some 1,200,000 acres are located in the Grand Coulee Reclamation Project. How can this area best be developed? Along what lines should land-use be directed? These are major problems confronting a large group of researchers. The investigations now in progress provide an excellent example of the part that research can play in promoting sound regional development. Some 28 inter-related problems have been outlined, each of which calls for specialized study. This cooperative, coordinated research program is attempting to resolve in advance of settlement just how the region can best be developed. These scientists are surveying and classifying the soils, determining land-use capabilities under the physical and economic conditions that will obtain, designing the most effective water distribution system, analyzing potential marketing problems, and plotting the settlement pattern. On the basis of experience in similar types of areas, they are attempting to determine for the Columbia Basin project the optimum size of farm units, the crop systems best suited to the various parts of the area, the potential water requirements of each soil type, the controls likely to insure proper land-use, the optimum rate of settlement, the necessary economic and social facilities that should be provided, and so forth. This piece of cooperative research should provide complete and accurate information upon almost every aspect that will affect the lives of the new settlers. If put into action, the mistakes usually associated with pioneer settlement should be minimized—if not avoided. This type of comprehensive research should be duplicated in other parts of the region in order to insure the wisest possible land-use.

Forest lands comprise 36% of the entire area of the Pacific Northwest, contain 48% of the remaining sawtimber of the United States, and supply half the national output of soft-wood lumber. Lumber constitutes 63% of the railroad tonnage originating in the region and 87% of the inland-water tonnage. That one out of every ten persons gainfully employed is engaged di-

rectly in a forest industry indicates the regional importance of timber. Still more striking is the fact that industries based directly on the use of forest products give employment to 62.5% of all wage earners engaged in manufacturing. Obviously, problems connected with the growing, management, and exploitation of these forest and with the utilization of their products offer innumerable opportunities for research. Solution of these would have far-reaching effects upon the economic stability of the region. To neglect them will prove a major disaster.

One example will serve to illustrate the role of research in this field. Forest depletion is progressing at a dangerous rate. Annual cut, more than twice annual growth, averages around 10 billion board feet. Fire, insects, disease and windthrow cause an additional average annual depletion of approximately two billion board feet. At present annual growth is barely five billion feet although, with scientific management, it would amount to several times this figure. Nor is depletion uniform throughout the region. The more accessible areas such as Grays Harbor have suffered severely from over-cutting and the economic base of many communities has been seriously undermined. The stability and permanency of such communities are possible only when cut is balanced by growth in the area that serves their mills. Sustained yield management seems to offer the best solution to the forest problem. It involves, however, a host of inter-related problems in the fields of forestry, industry, economics, and government. Scientific silviculture, the development of new and improved logging techniques, the multiple uses of forests, the reduction of waste both in the woods and in the mills, forest ownership, protection, taxation, marketing, wood technology, administration, public policy, and legislation offer many problems that resaerch must solve before sustained yield management becomes a reality, before the forest industries are put upon a permanent basis and the future of scores of communities is assured.

Fisheries, both river and off-shore, have long played an important role in the economic life of the Pacific Northwest. In Oregon and Washington the catch amounts to over 150,000,000 pounds a year and yields an annual income of approximately $25,000,000. Of this salmon provides two-thirds. In addition, fisheries attract thousands of tourists as well as local residents. Scientific management is essential to the permanence of this regional resource.

For a long time ocean fisheries were considered inexhaustible and conservation received little consideration. Overfishing in streams and lakes, on the other hand, becomes apparent more quickly owing to the restricted area involved, and excites attention more readily. As modern commercial fishing expanded and techniques and equipment became more efficient, the effects of overfishing in the established fishing areas adjacent to the coast have become significant. The situation in regard to halibut is illustrative of what happened. Depletion was indicated by smaller catches per unit of equipment and by the desertion of once productive fishing grounds. Fishermen were faced with the loss of their livelihood. In recent years salmon runs on the Columbia, Fraser, and other rivers of the Pacific Northwest have seriously diminished and the need for corrective measures is urgent. Here is another rich field for scientific research that can have far-reaching effects, both economic and social.

Accurate information regarding the life history of all types of commercial and game fish is essential. This research should include such matters as pollution, siltation, and other physical conditions that disturb the normal habitat of the various species. Only when

this information is available will it be possible to evolve measures to put fisheries upon a sustained yield basis and to make them a permanent asset to the region. Research on the halibut has demonstrated what can be accomplished when regulatory measures are based upon scientific data. The halibut industry is now in a healthier condition than it has ever been—a condition that can be maintained indefinitely so far as the supply of fish is concerned. Similarly, full utilization of fish, and particularly of fish products, awaits the results of further research.

The present economy of the region is based chiefly upon the exploitation of primary products—lumber, agricultural crops, livestock, fisheries, and crude metals. Industrial development has not kept pace with the substantial increase in population of the past several decades. The per capita value of new wealth created in the region in all industries except those concerned with foodstuffs, lumber, paper, and allied products is far below the national average. This retarded development is attributed to limited local markets, distance from populous eastern markets, high freight rates, external financial and economic controls, and inadequate coordinated research relating to the regional economy. The extent to which these are controlling factors is in itself a subject for careful investigation.

Many of the primary materials produced in the Northwest are shipped to the great eastern industrial areas for processing and a part of them return in fabricated form for consumption within the region. To many people a rapid and considerable expansion of industries adapted to regional resources appears to be both desirable and practicable. This might conceivably involve the expansion or stabilization wherever possible of existing industries, the development of new techniques for converting industrial wastes into useful by-products, the establishment of new industries based on regional materials now processed elsewhere, and the utilization of resources hitherto untouched. To what extent are these objectives practicable? Through the medium of research it would be possible to determine in advance the specific types of industrial development most likely to succeed and costly experimentation by "trial and error" would be eliminated.

The vast output of rough lumber, most of which is exported in that form, appears to offer a wide field for the expansion of existing fabricating industries such as pulp and paper, furniture, and specialty building material. New industries utilizing wood wastes and low grade lumber to produce rayon, cellulose, lignin, and other chemical products on a large scale seem feasible. Here research has its role—research of the type that is being carried out in the Madison Forest Products Laboratory and by Federal and private interests connected with forests and lumber within the region itself. Besides technical research, many economic aspects connected with the lumber industry need scientific study. Such research can serve to guide the lumber industry along channels most likely to be of permanent benefit not only to the region but to the industry itself.

Considerable expansion in the production of specialty food products for which the Northwest has gained a favorable reputation is thought to be possible. The lines that this development should take, the extent of the markets that can be served, and the physical and economic handicaps likely to hamper production and distribution should all be carefully investigated in advance in order to increase present output and to prevent overproduction and wrong emphasis. Chemurgy offers a fruitful field for scientific investigations since the problem of effectively utilizing agricultural surpluses is of regional importance both from the standpoint of the farmer and from that

of the industrialist. Likewise, research to discover improved techniques, equipment, and marketing practices is essential.

Mineral and metallurgical industries offer possibilities for a much more intensive development than heretofore, since they play an almost insignificant role in the present economy of the region. The Northwest is reputed to possess large and varied mineral resources. The extent and quality of the different deposits is not accurately known since "only about 10% of the mineral area has been surveyed in sufficient detail to provide base maps, and detailed geologic maps essential to mineral exploration are available for only approximately 5% of the area. Hence, the question of whether local deposits of iron ore, magnesite, allumina clays, etc., can be economically worked remains to be solved. The availability of large blocks of low-cost Columbia River hydroelectric power may justify the establishment of a wide variety of electrometallurgical and electrochemical industries. Which shall be developed? Where shall they be located? To what degree can they be developed under existing conditions of production and distribution? The Bonneville Power Administration is carrying on a number of "feasibility studies" to determine the answers to these and many other related questions. Some years ago a series of successful studies of this type were made by Cincinnati to provide the information necessary to guide industrial expansion there. Similar research is necessary in the Pacific Northwest.

Pertinent to any development of mineral and metallurgical industries is the need for continuing technological research of the type carried on in the Engineering and Mining Experiment Stations and in the laboratories of industrial organizations. Through this medium special techniques and equipment are being developed to deal with materials and conditions peculiar to the region.

Industrial promotion should, therefore, be based upon the results of research, without which orderly and logical development is impossible. Industry offers a challenge to a very diverse group of researchers to carry out the investigations that will assure permanent rather than transitory benefits to the region through successful rather than unsuccessful industrial promotions.

Sufficient examples have probably been cited to indicate that research has a vital role in promoting orderly and logical economic development. Two conditions, however, are essential: (1) close cooperation among physical and social scientists, technicians, and administrators to secure coordination and eliminate duplication of effort, and (2) the results of research must be made available to all who can use them so that they can be put to work.

Fire Control Methods of the Forest Service Northern Rocky Mountain Region

A. G. LINDH*

Chief of Division of Fire Control
U. S. Forest Service, Missoula, Montana

When the history of the West has granted perspective, the early day forest ranger will appear as one of the most resourceful of her pioneers. Tenacious, self-reliant, ingenious; an expert at using little to accomplish much; developing from the useful about him new tools and methods of work, and assimilating them with rapidity; he represents a part of Forest Service history which must be taken into account when considering present-day fire protection methods. Success in fire control today still largely depends upon the ability of the individual to use little to accomplish much.

Progress has been consistent since 1910 measured in reduction of area burned. From an annual average high of 23,797 acres destroyed per million acres protected in the half decade of 1910 to 1914 to a low of 1,023 acres annually per million acres in the half decade of 1935 to 1939 is a reduction which gives reasonable assurance that public forest values can be not only maintained but also increased.

This progress has apparently not increased the cost of fire protection during the past 15 years. However, a complete basis for comparison is lacking. The regular appropriation for fire protection added to the emergency fire fighting costs and averaged by half decades indicates an annual cost per acre of 3.6 cents during the period 1925-1929, 4.2 cents for the period 1930 to 1934, and 3.1 cents for the period 1935 to 1939. Excluded are the depreciation and maintenance costs of improvements, most of which are used also for other activities besides fire protection. On the other hand there are included rather large costs for the building up of capital investment in equipment.

The fire protection work of the Forest Service has profited most from the experience, knowledge and skill which has contributed to its planning. The men of action who could turn a plan into accomplishment have from the beginning remained the foundation upon which plans might be built; but planning is a progressive art which must continue as knowledge increases.

A fire control plan has been defined as a "comprehensive plan of action based upon facts and findings derived from thorough analysis of the several phases of the entire fire control problem". The objective is two-fold.

1. To determine the need for curative measures from the standpoint of applied fire control effort.
2. To determine definitely and specificially what is to be done in order to meet the need under varying degrees of fire danger at a minimum cost.

The determination of what consittutes satisfactory fire protection involves so many facotrs that a definite and changeless policy can hardly be expected. The "economic" or "least-cost" objective was the first one developed and its influence on fire control planning has been considerable. That theory recognizes that damage or loss is one of the costs of fire and advocates that amount of expenditure which produces the least total cost of preparedness plus suppression, plus damage. The origin of this concept is credited to Roy Headley who described the "minimum cost objective"

*H. T. Gisborne and R. L. Hand gave valuable assistance in the preparation of this paper.

in the California regional suppression manual of 1916. About a year later Elers Koch developed this objective independently for the Northern Rocky Mountain Region and in 1928 the late Howard Flint published a comprehensive study covering trends since 1910 in relations between the three factors in Region One.

A closely related theory known as the "maximum allowable percentage of burned area objective" was accepted by a Washington conference of Regional Foresters in 1930, and as a result, such an objective was set up for each forest type in the United States. However, later investigations uncovered the fact that a high degree of chance in several factors enters into the probability of attaining it.

The third and most definite objective that of "control within the first work period" is the forerunner of the present ten o'clock control policy which is now in effect and which has governed all fire control planning since it was adopted in 1935. This policy states that the objective shall be to control all fires as quickly as possible with available forces but not later than 10:00 a. m. of the day following discovery. Thus we have an objective that is understandable and one that is not in conflict with either the "economic" or "permissible percentage of burned area" thoeries.

Instigated by Regional Forester E. W. Kelley, a fire control planning project more comprehensive than any heretofore attempted was begun in 1931 in Region One. This work was conducted jointly by the late Lloyd G. Hornby, formerly supervisor of the Clearwater and Flathead Forests, and Harry T. Gisborne, in charge of Fire Research in the Northern Rocky Mountain Experiment Station.

While advantage was taken of all previous work on this subject which could be applied to Region One conditions, certain methods were original in several respects. The most important of these may be listed as follows:

1. Integrating of all danger factors into a single rating for a particular area.
2. Requirements for detection correlated with those for initial attack.
3. Road systems designed to satisfy the combined needs of initial attack. Light reinforcement and heavy reinforcement with the least expense.
4. Mapping of fuels according to probable rate of spread and resistance to control and the use of fuel classes rather than cover types to determine requirements of speed and strength of attack.

As a result of this project, Region One has developed a fire control plan which governs the action on 17 national forests, aggregating 28 million acres under Federal protection. From the facts established through classification of fuels, weighing of the occurrence factor, and other measurable elements, each forest has been given a rating which determines its relative intensity of protection warranted under each step in the varying fire danger scale.

On the basis of these findings, a guard force of some 1200 men is hired, trained, equipped and distributed over the region in such manner as to give maximum protection cost and at the same time contribute to the improvement of the forest properties at all times when not actually needed for prevention, detection or suppression.

It should be noted that regular appropriations by Congress have provided for only slightly more than two-thirds of this organization. The additional guards needed are now employed only after the emergency has arisen. This method of financing precludes the selection and training of as good men as should be obtained for such work. It may, therefore, be said that the fire plan in its entirety has never been made

effective and the tests so far made of it cannot be accepted as a final indication of what the most economical and effective forest fire protection may be in the future.

Fire control planning is not new. However, modern planning strives to substitute measured facts for experienced opinions. The old-time ranger rode to the top of a bald hill, surveyed the country and said, "This is a fine place for a lookout. I'll have a camp up here next summer." Or perhaps he left his saddle horse and hiked across a drainage where windfalls lay like jackstraws on the ground, meanwhile considering in his mind just what he would do if a fire occurred in that particular creek bottom. This was planning. In modern planning, hundreds of hills and mountain peaks are carefully mapped, sorted and compared in all sorts of combinations in an effort ot get the best detection coverage with the fewest number of men.

Fuel surveys are made and all areas are classified on the basis of how rapidly a fire may spread under certain weather conditions and how long it will take a certain number of men to control a certain unit of perimeter. These in turn are converted into terms of hours of elapsed time which may be allowed, and the results used to determine the size and distribution of man power, location of transportation facilities, kind and amount of equipment, poliices regarding preparedness and a host of other things.

In the matter of fire prevention, modern planning recognizes that mere numbers of people occupying the forests are no criterion of the special risk involved. Fuels to burn, weather conditions conducive of inflammability and causitive agents—all must be present to constitute a risk and the lack of any one of these three elements obviates the immediate risk at that particular time and place. Fire control planning analyzes each special risk zone and prescribes remedial measures to meet each set of conditions.

Presuppression planning is aimed at the development and maintenance of what may be termed the first line of defense. After the need has been established for a certain intensity of coverage for a given unit, an organization is set up to meet this standard. In recognition of the responsibility of the individual as well as our obligation to economize where this can be done without undue sacrifice in efficiency, local residents are used as cooperators to the fullest extent possible. In some of our eastern Montana forests, for example, resident cooperators supply the greater part of both detection and smokechasing facilities. Hired guards are placed only when the required standards cannot be met otherwise, and even then, the development of local cooperation is kept alive through continued personal contacts, educational campaigns, and training programs.

The study of past records and our knowledge of fire behavior have shown conclusively that even with the most intensified prevention and preparedness measures in effect, the occasional fire will "get away". When just the right combinations of fuels, fire danger and ignition occur simultaneously, human effort is powerless to prevent rapid spread beyond the smokechaser or small crew stage, hence the need for what is termed suppression planning.

Suppression planning is directed at controlling those occasional fires that "get away", just as presuppression planning is aimed at reducing the number of such fires. Suppression plans deal largely with the following problems:

1. Selection and development of overhead to act as fire bosses, sector bosses, foremen, scouts, timekeepers, etc., on project or crew fires.
2. Organization, training and devel-

opment of mobilization plans for forest crews such as CCC, blister rust, road crews, etc.

3. Development and training of cooperating agencies and individuals.
4. Organization of facilities for the hiring of firefighters when organized crews are exhausted.
5. Development of dispatching technique. This is a matter of getting factual material into such form as to be usable by fire dispatchers. Some of it may come as a result of investigative studies of fire weather, inflammability, etc., and some may be the result of refinements in the cataloging of facilities that already exist.
6. Zoning of special hazard areas with specific action plans to govern control of crew fires which may occur in these areas.

While the three basic components, namely prevention, presuppression and suppression, cover the entire field of fire control planning, there are several other subjects of sufficient importance to merit special mention. Since one of the principles upon which such plans are based assumes the output of a man as equivalent to a certain fixed unit of energy, it is necessary to see that the men are (a) properly selected, (b) well trained and (c) fully equipped.

Consequently personnel, training, and equipment are all of vast importance in fire planning and while they overlap and form an element in the three major components, each requires special study and treatment in itself.

Equipment planning concerns first of all the determination of the kind and amount of equipment needed for different units with different kinds and degrees of hazard. It establishes a level, determined by a study of probable "peak loads" of fire occurrence, transportation facilities, etc., to which each forest and group of forests will be self sustaining. Beyond that level, studies of regional "peak loads" and comparisons of ground and air travel speeds, in turn establish the extent of centralized equipment caches. The correlation of advances in the development of new equipment with studies of needs on the fire line is also a function of the equipment phase of fire planning.

Training is and always will be a big item, and fire control planning endeavors to insure that training is aimed at developing a well-oiled machine.

Since there is no industry in which the requirements are at all comparable to those of the fire control organization of the Forest Service, our training program has been developed from scratch and no small part of it has been the training of trainers.

Selection and retention of qualified men is undoubtedly the most important as it is in one sense the most difficult of the many problems that the Forest Service has to face. The Northern Rocky Mountain Region is characterized by short, intense fire seasons, with a total fire load exceeded by no other region and crammed into two or three short months. Hence, the difficulty in retaining a stable organization, which can only be realized by offering men employment with enough permanence to insure a reasonable standard of living. The difficulty is not in the lack of work to be done. Actually, a great deal of highly important administrative work is at a standstill during the peak of the fire season, because every able bodied man is on the fire line. And there is not the slightest question but that the entire guard force could be employed on productive forest work twelve months in the year—if funds were available.

Fire control plans, like any other, are dependent on men to bring about their accomplishment. Mechanical developments may reduce the amount of labor needed on a given job but does not

minimize the importance of either the brains or the brawn needed to keep the machines running. Until we can drastically reduce the turnover in our seasonal force by offering a reasonable period of employment, we will continue to be seriously handicapped in putting our plans into effect.

Fire control planning obviously must aim at developing a plan with enough flexibility to enable the manager to meet present or probable changes in the conditions which cause fire to burn at any given degree of intensity. These conditions are primarily weather, and are divided into short and long time changes.

The short time changes may require hourly or daily action by the responsible organization head.

The need for increased knowledge of the several factors which most directly affect fire danger was recognized in the Forest Service research program as early as 1922 when H. T. Gisborne began his work at Priest River, Idaho.

The goal of forest fire danger research is as simple as it is difficult. It may be stated as follows:

To increase knowledge of the factors which govern fire danger to permit the distribution of fire control facilities and man-power required for each particular forest unit and current weather so that under reasonably effective administrative management adequate fire control will be insured, and at the lowest possible cost.

It is universally conceded that forest fire danger is a result of several separate factors. The method used in the Northern Rocky Mountain Region employs measurements of fuel moisture, relative humidity, wind, causative agencies and visibility distance. These measurements are combined into a convenient meter from which an index fire danger rating may be readily concentrated on refinements both in the accuracy of measurements and in the application of them to produce index ratings.

Up to this time fire danger has dealt only with what has occurred. Since action so far as possible should be aimed at preparing to meet danger before it occurs, the forecasting of the weather conditions which will affect tomorrow's fire danger has become increasingly important. The United States Weather Bureau has provided fire weather forecasts for a number of years. It is an art which has progressed. The forecasting for the past few years has been quite satisfactory and will become more so as increased knowledge and facilities become available. The extremely heavy dry lightning storm which swept the region on July 12 and 13, 1940, was forecast a full day in advance. Considerable planwise action was thereupon taken.

It should be pointed out that both the fire danger measurement methods of the Forest Service and the fire weather forecasting of the Weather Bureau have been made available to all other fire protection agencies. Undoubtedly the use of these facilities has been of much value to them as well as being indispensable to the Forest Service.

The long time trends and changes in climatic conditions are of great importance to fire control planning but our knowledge is very limited due to an almost total lack of research effort in this field.

Fragmentary but startling data showing critical reductions in precipitation over the Inland Empire and Northern Rocky Mountain country during the past several decades have however been assembled.

Dr. Robert Marshall's study of the influence of precipitation cycles on forestry (see the Journal of Forestry for April, 1937) disclosed certain cyclic trends of precipitation in this region during the past two and one-half cen-

turies. He summarized his finding as follows:

1. The climate of northern Idaho has exhibited distinct wet and dry periods, varying in length from 20to 40 or more years.
2. The 20 years since forest fire protection was begun appear to have been the driest score of years in two and one-half centuries. (His study was made in 1926. It has since become much drier.)
3. Such variations in the amount of precipitation have a vital and often neglected bearing on the practice of forestry.

The compilation of precipitation records of the Weather Bureau as far back as they are available corroborates Marshall's findings. Precipitation records and trends in graphic form for a number of representative western Montana, northern Idaho and eastern Washington stations have been compiled by R. T. Hanna of the Weather Bureau. A significant downward trend in precipitation is obvious at all stations. Rainfall for the western half of the Northern Rocky Mountain region since the period 1900-1910 has decreased by 10 to 34 percent. The average reduction for all stations is about 21 percent in the short period of 30 years. This downward trend in precipitation has been accompanied by a significant increase in mean yearly temperature. Other data show that this downward trend in annual precipitation has, as would be expected, produced a marked decrease in our already insufficient summer or fire season rainfall.

The annual measurements of the flow of the Columbia River since 1879 corrected for irrigation loss and the Missouri River since 1885 give potent evidence of the importance of these same precipitation trends. The flow of the upper Columbia has decreased nearly one-third since 1895. Less than one-half as much water now flows out of the upper Missouri watershed as in the period ending in 1895-1900. The dangerously diminishing precipitation in the headwaters of the Missouri River is clearly evident n Figure 47 of Senate Document No. 199, "The Western Range".

The significance of these trends most certainly should be faced. No long time planning for fire protection will be worth while that does not recognize not only the probability of changed climatic conditions in the future, but especially the EXISTENCE of conditions now upon us. Provision should be made for systematic and more complete study of the subject for the benefit of fire control paritcularly, and of almost equal importance for all land use planning. Study of current and historical data should seek to develop means of forecasting cyclic changes.

These are some of the principal factors upon which fire control planning has been based. The degree to which the plan has been made effective by appropriations from Congress has been indicated. What are the results? How effective is that plan in action? What are the methods used to carry it out? I will touch only upon the highlights, and can do that best by briefly describing what happened during the 1940 season.

The region, comprising the national forests of Montana, northern Idaho and northeastern Washington, was stricken by a larger number of fires during a season of considerably more than average intensity, than ever before experienced. Every forest exceeded its previous 10-year average in number of lightning fires and all but four established new all-time highs. Five forests reported from more than twice to nearly three times the number recorded in any previous year and even over the region as a whole the previous high record was more than doubled. With one or two exceptions each 10-day statistical period throughout the saeson showed more fires started than during the same statistical periods in any of the preceding ten years, which is as far

back as the comparisons have been made.

The fires were not only concentrated in many places to give the organization new tests in meeting unusual overload conditions, but were also distributed in time and space to permit an exceptional trial of the region's staying power and uniformity of ability.

The number of man-caused fires was also increased but thorough analyses forbid any very alarming conclusions. Certain classes of man-caused fires actually decreased. Those which increased require specific action for the specific area where they occurred.

The total area burned over was 48,320 acres, or 1,474 per million acres protected. This amounts to fifteen hundredths of one per cent of the total national forest area within the region. Compared with the average loss of nearly 24,000 acres per million acres protected during the half decade 1910-1914 or with the 13,000 acres per million acres lost during the half decade 1915-1919, the remarkably small loss during 1940 is very encouraging.

The basic unit of organization is the individual lookout firemen who comprise over 75 percent of the man-power in the regular fire control organization of Region One. Each of these men is stationed alone and has responsibility for both detection and fire suppression in an area which changes in size as fire danger changes.

The other 25 percent of the organization is made up of men who are located at or work out from ranger or other central stations. They are the dispatchers, supervisory personnel, service men such as packers and truck drivers or suppression men, stationed thus centrally by reason of exceptionally heavy fire occurrence.

The lookout fireman has two primary functions. First he is a detector who must remain constantly on watch and in communication with a central dispatching station. The facilities and skills that have been developed to obtain discovery while fires are small and the essential accuracy in reporting them cannot be described here. However, it is interesting to note that almost exactly the same lookout methods are now being used in the city of London for the discovery and reporting of incendiary bomb strikes and fires.

Second, the lookout fireman is depended upon for the primary fire suppression work in the area which he can reach more quickly than any other member of the organization. When he is dispatched to control a fire other nearby lookouts attempt to give coverage while he is gone or his lookout is covered by an emergency guard drawn from the nearest available source. Even where replacement coverage of the lookout cannot be obtained the suppression job is given first priority.

The lookout fireman usually travels at least part of the way to the fire on foot and through rough terrain which precludes the use of elaborate equipment. His complete pack weighs 17 pounds and is the product of much ingenuity through 30 years of experience and development. With it he is equipped to suppress any forest fire if he arrives soon enough. The lone smokechaser is the man who truly must accomplish much with little. His success is outstanding. His feats are heroic; but there is no writer to tell the tales. His battle is fought alone. His success is known only by the sudden disappearance of a distant smoke. Of the 3,598 fires fought in the region in 1940, there were 2,703 controlled at less than one-fourth acre. An additional 699 were controlled before they reached ten acres in size. Only from such cold statistics can we gain a small realization of his importance in carrying out the plan.

Where there are roads, more elaborate and correspondingly more effective equipment is used. As an example, light water tankers with a full complement of hand equipment are coming into wider use. Light tractors specially

FIGURE 1. Increasing use is being made of the "Brushbuster" which is a specialized fire line building machine developed from the "Bulldozer".

FIGURE 2. The Bosworth trencher, still in the development stage, does the job of 30 men.

developed for fire line construction are finding a useful place in suppression work. A newly invented one-man machine, the Bosworth trencher, is going through successive stages of development and promises to add greatly to the effectiveness of the small smoke-chasing crew.

The dispatching function is an important one. It is performed at several levels, although primarily the district ranger or a designated assistant has the full responsibility and authority to initiate suppression action consonant with the need on his district. The swift recording of information from lookouts, the precise analysis which follows, and the resultant distribution of the too meager available forces during dry lightning storm concentrations—this is fire control work of the highest order.

When a ranger district fire load exceeds the capacity of the local force, the district dispatcher turns to the forest supervisor or his designated alternate for help. Dispatching at this, the forest supervisor's level, requires of him the same assembly of less detailed but nonethe-less specific fire and organization information from each of his ranger

districts as the ranger obtained from his lookouts. The forest supervisor then must draw on his available forces to meet the need on any district or districts, as long as he has man-power left.

When the suppression forces of any national forest are inadequate for local needs, the forest supervisor then immediately calls upon the Regional Forester or his designated alternate. At this level, dispatching necessarily deals less with details of the need and depends more upon briefed summaries which will permit regional balancing of individual forest needs against the available forces. It should be made clear, there are no regional forces. All man-power in the region is under the direction of the 17 forest supervisors comprising the regional organization. The regional dispatching function is therefore to know the situation of each forest and be in a position to decide without delay which forest can best spare the man-power needed elsewhere.

The communication and transportation facilities, the road system, and the skill which permits rapid inter-district and inter-forest mobilization of forces to quickly meet local emergencies are probably the outstanding contributions to fire control of the past two decades. Development of the shortwave radio, airplane facilities, efficient motor trucks, the organization and training of fire fighting crews in the CC and outside of it and the construction of our road system were essential. True, the road system is not complete, landing fields and trails need maintenance and improvement, and radio requires further development, yet progress has been great and dividends are being returned to the public.

We have described briefly the place of the individual lookout-firemen and the dispatching job in fire control. What happens when the local force has more fires than it can handle or when a single fire spreads so quickly that it makes a larger suppression job than can be accomplished by local firemen? The possible courses of action are several, depending upon circumstances.

When the problem comes from having more individual fires than the available firemen can control, the administrator transfers skilled firemen from one unit to another. Firemen so transferred are used to find and control small fires as they would in their "home" district.

When the problem arises from a large fire requiring more men than are available locally, action is designed to obtain organized crews. During the past eight years the Civilian Conservation Corps camps allotted to the national forests of the region, have been the principal source of organized man-power. In addition, there have been some road and trail construction crews available until just recently, who were the most effective of all crew workers. Blister rust crews are used to a limited extent but the importance of blister rust work requires that interference with their program be kept to a minimum. Local cooperators who are willing to leave their regular work and go out on fire fighting jobs have been very effective in many parts of the region.

Techniques and methods of fire suppression have advanced during 30 years but to a lesser degree than the facilities for control. The problem of obtaining greater control production per man-hour worked is the most challenging one in fire control work today. It is being attacked on two major fronts. First, every effort is being made to develop better organization methods. A method of fire line production is being tried which apples the functionalized assignment principle of the assembly line but with the crew working while walking past the job rather than having the job moved past the worker. The method appears to have many advantages over the several older methods of individual sector assignment, particularly on larger fires.

The second basic approach to solution of the problem is in the development of fire suppression strategy and

tactics and the training of fire control overhead in their use. In simple language, we are trying to learn more about how to fight forest fires and to make that knowledge available to others.

The method of direct control suited to smaller fires has progressed very rapidly. Highly effective work is generally accomplished if the workers have been properly trained. The facilities for training have been greatly improved and increased in the last ten years.

In theory it appears desirable that small fire practices should be ahead of those proving effective in the control of large fires. Since all fires are small at the start it might be hoped that effective work on small fires would prevent any of them from becoming large. Actually, some fires "explode" to large size within a few minutes so that initial control efforts must be those effective on large fires. From one-half to three-fourths of the cost of fire protection result from this latter type. It is apparent therefore that effective and productive work by large crews on the larger fires is highly essential.

The total organized crew workers available in the entire region and made up largely of CCC forces, amounts to no more than a total of 4,000 men. Several times during the summer of 1940 there were needed far more than this number. The additional men up to a peak of over 5,000 making a total of over 9,000 at one time, had to be employed in local or distant labor markets.

Fire crews are organized very much as are the units of the Army. Seven workers form the smallest crew unit and are directed by a leader or straw-boss. Three such crews are organized under the direction of each foreman. Thus a twenty-five man crew becomes a basic unit of organization which can be transported as a unit in the one and one-half ton trucks best suited to use on the roads which make up the national forest system.

From two to six foremen and their crews comprise a sector organization, working under the direction of a sector boss. If the fire can be handled by an organization of no greater size the fire boss may also become the sector boss. The sector organization in addition to the above has one or more scouts, a radio operator, and a camp and service organization to supply all facilities for feeding and sleeping the workers.

A fire large enough to require the organization of two or more sector crews is placed in the charge of a fire boss to whom the sector bosses are directly responsible. If the number of sectors exceed four, or if the topography is unusually difficult a further division of responsibility is frequently necessary. A division boss might be responsible for from two to six sectors covering from four to twenty-four miles of fire perimeter. On an extremely large fire such as the Pete King on the old Selway Forest in 1934, which had 410 miles of worked perimeter, the division would still be the largest unit of organization working under the fire boss.

A fire boss under the Forest Service plan of organization is designated for each crew fire no matter what its size and given full authority and responsibility for all the action to bring about control.

The supplying of proper food, equipment and comfortable beds, exactly when and where needed, is no mean accomplishment. During July 13 and 14, 1940, approximately 9,000 men were mobilized, organized and supplied in approximately 90 separate units, distributed on the larger fires throughout the mountains of western Montana. A few days later all of this large force was demobilized and each man was returned to his camp or home, which in many instances was four to six hundred miles away. When the job was finished less than twenty-four hours' food supply was left on hand. At no time was food on hand for more than one day at a time, yet every man received

three or more balanced and planned meals every day.

The pre-season preparation of equipment and supplies and facilities for moving them is vital. Crew equipment and supplies are maintained in compact, sealed units with each available sure supply of labor. Much of the equipment must, however, be maintained in central warehouses. Twenty-five and fifty-man units are basic and developed to fit the method of crew organization used.

Light motor trucks must be available for transportation where part of the travel route will be over mountain roads. Commercial freight vans and the railroads are used to a great extent for long distance hauls.

Pack mules are essential and must be for the most part maintained by the Forest Service, since there are almost none available to rent. Each forest maintains only sufficient pack mules to meet their normal need for all kinds of forest work. Emergency fire needs cannot be met entirely by inter-forest transfer although practiced to the utmost. To meet the need for extra pack animals for peak loads the Region maintains a central mule supply or Remount Station, where from ten to twenty strings of ten head each are kept, ready for fire use. High speed specially constructed transport vans are kept available to move them anywhere in the region, within a comparatively few hours.

Even with the avaliable motor trucks and pack mules, the supplying of crews on many back country fires is too slow. Also, the total number of mules is frequently inadequate for emergency conditions; to meet the need for faster delivery of essential supplies and equipment, increasing use has been made of airplanes and parachutes. Standard equipment and supply bundles with no special packing or wrapping are dropped safely by 'chute into the roughest terrain. The method permits the development of such skill that rarely does the parachute bundle miss the target by over 100 feet.

The airplane service used in this work is obtained under contract with private air transport companies. During 1940 over 4,000 bundles weighing a total of 297,000 pounds were delivered direct to fire crews in all variety of rugged timbered areas. The costs of delivery in many cases were less than they would have been if packed by mule. In addition there was the frequently very valuable saving of time, which cannot be measured in dollars.

From the use of parachutes for the delivery of supplies, it was only natural that foresters would develop the idea of delivering men by parachute. The need was always there, particularly in those back country areas where the number of fires frequently exceeded the number of local lookout firemen, or where a fire had escaped and was many hours' travel time from the nearest reinforcements.

The use of parachutes by the Forest Service has drawn much attention during 1940, notwithstanding the fact that experimental work was under way (and not over 150 miles from Spokane here in the State of Washington) for nearly a year before Europe headlined parachutists in their phantasmagoric warfare.

The parachute experiment was started in 1940 on a financial shoestring. The project began with only enough equipment for eight jumpers in Region One and eight in Region Six. Experimental tests conducted in the North Pacific Region near Winthrop, Washington, in 1939 determined the selection of equipment, jumping techniques, recruitment standards and training plans. The 1940 objective was to make practical tests of the many problems of administrative application under actual fire conditions. Only the most skilled firefighters were recruited for the work and a rigid physical examination was required of all candidates.

After a ten-day program consisting of

several days of ground training and from five to ten jumps for each man, the squad was moved back to an emergency landing field at Moose Creek on the Bitterroot Forest. Here, just 45 minutes' flying time from Missoula, in the heart of a two million acre wilderness of rugged terrain, heavy fuels and high occurrence of lightning fires, the men took up their abode for the summer. When not engaged in fire suppression or in ground training or drill they worked on improvement of the landing field, thus contributing to an urgently needed fire control project as well as keeping in good physical condition.

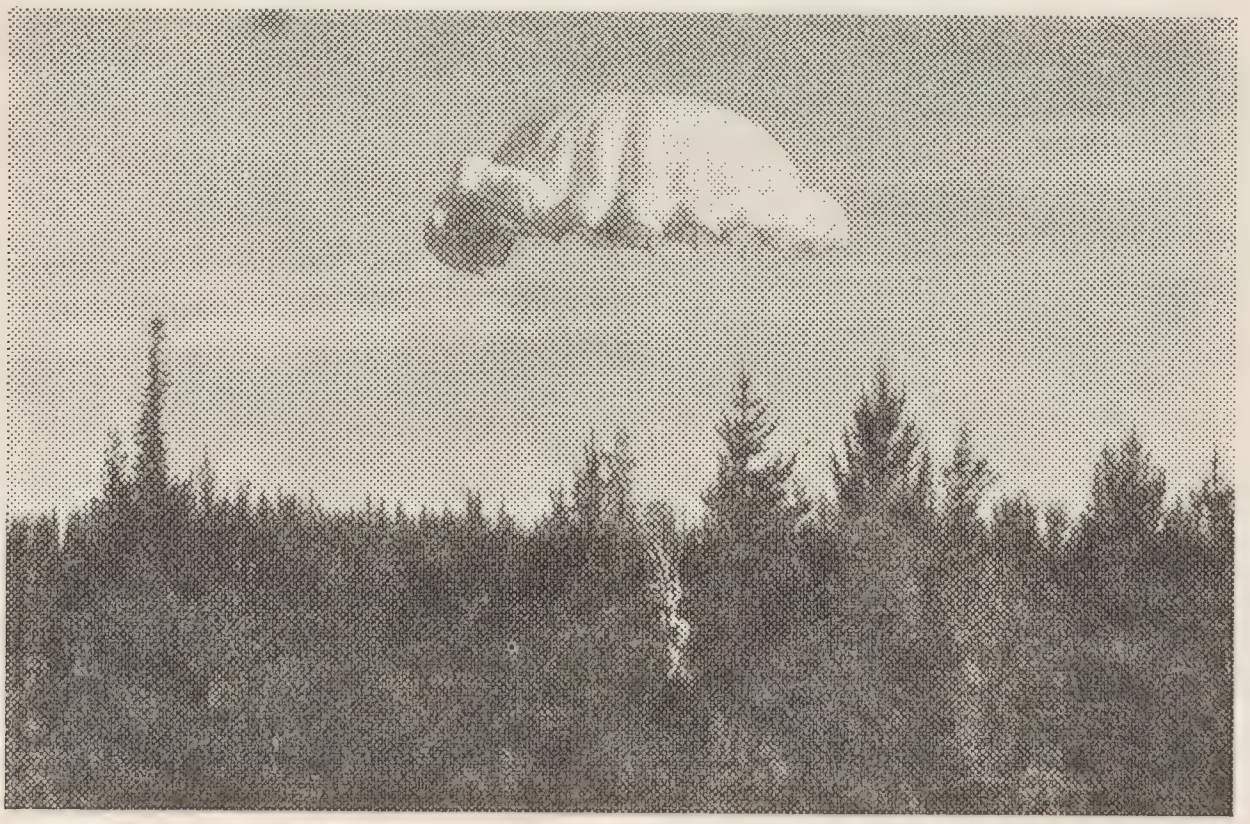

FIGURE 3. The use of parachutes opens the way for better fire control in the back country.

During the heavy concentration of lightning fires between July 12 and 20, the excessive number of "back country" fires made it a most difficult job to select those which were potentially dangerous and yet small enough for effective work with not more than two parachuters per fire. The problem was still further complicated by the heavy schedule of airplane freight hauling to the numerous project fires that were burning in remote areas. Nevertheless, the jumpers were dispatched and efectively controlled nine lightning fires during that period.

On the evening of August 20 a dry storm hit the Moose Creek district, setting 16 fires in an area occupied by eleven men. The farthest of these were 10 and 12 miles respectively, from the nearest road. Early the next morning four smokejumpers were dropped near these two fires with the result that they were controlled before reaching one-fourth acre size. Of the other 14 fires, for which there were no parachutists, six were in similar fuels with comparable possibilities and somewhat closer to roads, yet they ran from 100 to 1,100 acres in size and cost from $2,000 to $13,000 to control.

The last jumping was done on August 31 when the three jumpers then available were dropped on a threatening four-acre fire which they were barely able to hold in check until ground reinforcements arrived.

When a Forest Service contract freight plane crashed in one of the roughest parts of the Bitterroots in mid-July, one of the parachuters who is an advanced student in first-aid was dropped at the wreck and his skill and equipment probably saved the life of the one survivor. This form of rescue work opened up a field of parachute use for first-aid and medical service in the mountainous country of the region. Funds permitting, the plans for 1941 contemplate the organization of a rescue

squad including a hardy young doctor who has volunteered for this service. He has already made two jumps and will undertake further training as soon as such a project can be organized.

A comparison of the suppression time in costs between parachute and ground crew action was made. The costs of ground crew action were of course, estimated and are therefore admittedly debatable. Nevertheless, experienced men in the best position to make the comparison objectively agreed that during 1940 a saving was made in suppression costs of more than three times as much as the entire parachute project cost. No attempt was made to estimate the value of the resources saved. Most of the savings occurred on three fires of the nine controlled by parachuters.

Probably the most important questions involved in the use of parachutes were whether experienced fire guards could be recruited for jumping and whether they could jump safely in rough, timbered country. The results of the 1940 season give strong proof that the answer is "yes" to both questions. Seventy-eight jumps were made, twenty of which were in country representative of our worst problem areas in the region. There were no injuries during actual fire suppression and the two that occurred in training were very minor in nature. Damage to equipment was astonishingly small, permitting the tentative establishment of a five-year depreciation period for the parachutes and jumping suits.

Tentative plans for 1941, funds permitting, will require five squads of eight jumpers each, one of the eight to be squad leader and rigger. One squad may be experimentally stationed at centrally located Missoula, where a contract plane will be immediately available. The other four would be stationed at outlying wilderness fields. The squads would be designated in priority for inter-forest dispatching, the central squad at Missoula to be number one. As the fire danger increased, the squads would be placed in a stand-by status and might be transported ahead of actual need to the field nearest an impending outbreak of fires.

A preliminary analysis was made this fall which indicates an average of 238 fires per year on which smoke-jumping might be expected to pay dividends. Debatable as this figure is admitted to be, it is based on zoning of areas away from roads, in which worse than average fuels, high danger days and normal length of fire season in its relation to occurrence, are all given consideration.

It is an established principle in Region One fire planning that under given conditions a few men in one hour are the equivalent of many more men arriving three or four hours later. From this principle, a table of equivalents was developed which has been recognized and in use for several years. This same principle applied to the use of parachute firemen indicates that a minimum of 50 jumpers could be used to good advantage in a normal season in Region One.

The parachute development from a planning viewpoint is significant only in that it opens the way for more effective follow-up on fires in the back country which is a small but important part of the whole problem. Not only is there promise of lower costs, but more important, there is an indication that many of the huge wilderness areas of the nation may be safely left roadless and in their primitive state, with only the floating parachutist to mark the control of man over the primitive.

Most of the national problems of conservation regrettably lack dramatic appeal to impress themselves upon enough people to bring timely solution. Destruction of the earth's life-giving top soil in inches per century mean little to a people whose daily lives are measured in miles per minute or hour. Perhaps scientists will find a way to deliver essential knowledge to the people by parachute.

The Significance of Bacterial Spore Antigens in Taxonomy

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A species has been defined as a "cluster of individuals usually possessing some common characteristics and gravitating to a definite modal point in their variations."* Taxonomy is devoted in large part to determining these common characteristics and the limits of variation for any given character.

Morphological differentiations have provided the basis for most botanical and zoological classifications and have been of value in the separation of bacterial families and genera. Because of the morphological simplicity of bacteria, species differentiation on the basis of structure has been all but impossible and physiological and serological criteria have been relied upon.

The use of serology as a means of species identification has been based upon the very logical hypothesis that species should be characterized, in part, by species specific proteins. Serology makes possible the discovery and identification of these species specific proteins or haptenes and thus becomes a valuable taxonomic tool.

But the application of serology to taxonomy is complicated. The bacterial cell is a system of many chemically distinct substances, the most important from a serological viewpoint being the proteins or antigenic substances. Any serological reaction using the cell as antigen against a homologous antiserum depends on the number of different antigens present, their relative proportions and relative ability to induce specific antibody formation. Some of these antigens might conceivably be common to a genus, a species, a variety, or only to the individual cell. If the whole cell is used as an antigen the inevitable result is a mass of data too heterogeneous in significances to be interpreted. Species specific antigens must be discovered and tested individually.

The ideal procedure would be for the organic chemist to separate the species-specific compounds and to identify them. Possibly this may be accomplished in the future. There are only two other practical approaches. One is to separate portions of the cells and test each portion for the presence of species-specific antigens. Essentially the Lancefield technique for separating the soluble C substance has accomplished this for hemolytic streptococci.

The other method is to search biological material for instances where "Mother Nature" herself has probably concentrated species-specific material. Apparently such concentration sometimes occurs in bacterial endospores, which may be regarded as reproductive bodies.

The evidence in the literature is in favor of the view that the spore is antigenically distinct from the vegetative cell.[1-2] Krauskopf and McCoy, however, have reported that the bacterial spore is not antigenically distinct. The work is open to the criticism of poor control in that only alkali treated spores were used in their immunizing procedure. In their most recent work Howie and Cruickshank (1940), from a series of well controlled experiments, drew the conclusion that "spore antigen is separate and distinct from the antigens of the bacilli to which the spores give rise in germination." They undertook their work with the intention of determining the validity of Krauskopf and McCoy's conclusions.

In my work suspensions of untreated spores were injected intravenously into

*Dobzhansky, T. 1937. Genetics and the Origin of the Species. Columbia University Press.

rabbits. The resulting antiserum agglutinated spores but not vegetative cells from the homologous strains. It was found to be impossible to absorb out the spore antibody if vegetative cells from the homologous strains were used as absorbent.

Spores are characterized by an extremely refractive substance. By gradually dissolving away this material in a five per cent solution of antiformin it is possible to demonstrate that the refractive substance is probably antigenic. Once the refractive property of the spore has been destroyed by antiformin (this is easily followed by observing with the microscope) it is no longer possible to agglutinate the residue spore material by use of specific spore antiserum.

In order to study the utility of spore antigens in bacterial taxonomy, 105 strains of aerobic spore formers were collected and subjected to a morphological (including method of spore germination), physiological, and cultural study. Each of ten rabbits received injections with spores from a single strain. In the case of the rabbit injected with *Bacillus simplex* spores, death occurred from unknown causes three days after the eighth injection. Attempts to produce spore antibody were unsuccessful in the cases of *B. megatherium* (C1), *B. mycoides* (C2), and *B. niger* (C10). Spore antibody was obtained from the six remaining rabbits using spores of strain S8 (*B. subtilis*), 42 (*B. subtilis* C4 (Marburg strain of *B. subtilis*), 14 (*B. agri*), C3 (*B. cereus*), and 7 (*B. megatherium*).

By relating the physiological, morphological, and cultural data with the data obtained by running agglutination tests with spores from all 105 strains on all six antisera, and agglutinin absorption tests in special instances, it was possible to arrive at the following conclusions:

1. Spores may possess one or more easily demonstrable antigens which in certain instances are group, species or type specific.
2. Three serological groups including four species are separable in the case of the small-celled strains studied.
   a. *B. subtilis* group, species: *B. subtilis* — equatorial germination without splitting along the transverse axis; nitrates reduced; glucose, sucrose, starch attacked; growth at 55°C., no growth at 15° and 10°C.
   b. *B. mesentericus* group. Species: *Bacillus vulgatus* — equatorial germination with splitting along transverse axis; nitrates reduced; glucose, sucrose, starch attacked; growth at 50° and 15°C., no growth at 55° and 10°C. Species: *Bacillus mesentericus* — germination by comma-shaped expansion; nitrates not reduced; glucose, sucrose fermented; starch usually not attacked; growth at 50° and 15°C., no growth at 55° and 10°C.
   c. *Bacillus agri* group. Species: *Bacillus agri* — polar germination; nitrates not reduced; glucose, sucrose, starch not attacked; growth at 55°C., no growth at 10° and 15°C.
3. *Bacillus cereus* shows a group specific spore antigen. Three physiological groups of *B. cereus* are observed.
4. At least one type specific spore antigen occurs in the case of *Bacillus megatherium*.
5. The standing of *B. mycoides* as a species is in doubt. The relation of some *B. mycoides* strains as rough dissociants of *B. cereus* is indicated. *B. mycoides* may be induced to yield smooth forms.

Are there any implications that arise from the fact that specific spore antigens exist and that they often have taxonomic significance? Further experi-

mentation and future experience will be the arbiter of the question. Nevertheless it may be wise to indicate four possibilities.

The first possibility is the more practical utilization of the Ascoli test for the detection of hides from animals infected with the anthrax bacillus. The Ascoli test is a simple preciptin reaction carried out by using an extract of the hide to be tested with an antiserum prepared against the anthrax organism. If the hide comes from a diseased animal it will be contaminated with antigenic bacillary material which is detected by the formation of a precipitate. Health officers responsible for eliminating such infected hides from imports might have their work facilitated if it is made certan that the antiserum used in the Ascoli test contains antibody against anthrax spores. If the anthrax organism, like other spore formers, proves to have spores with specific antigens, an antiserum against vegetative cells will not necessarily detect hides or materials that are contaminated with anthrax spores alone.

The development of any immunization procedure involving spore forming bacteria should in the future take into account the antigenic individuality of spores. Obviously most effective prevention or therapy would involve antibodies against both vegetative cells and spores. It is possible that in some cases immunization and therapy have failed in the past because the role of the spore as antigen was not taken into consideration.

It is well known that human beings may be allergic to specific bacterial antigens. Spore antigens may prove responsible for some hitherto unrecognized sensitivities. The allergy diagnostician should consider adding bacterial spores to his battery of test materials.

In the plant world many organisms beside the bacteria show the ability to produce spores. Many of these have spores with nearly similar and characteristic refraction of light, and ability to resist deliterious environmental effects more successfully than vegetative cells as have bacterial endospores. If these spores should prove antigenically different in some respects from vegetative cells the implication in botonical taxonomy may be the same as for the bacteria. The use of spore serology in identifying the difficultly distinguished fungus parasites of medical mycology may be expecially indicated. Medical mycology is in need of new ways of attacking its taxonomic problems.

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The Relation of Forest Production and Use to National Defense

W. B. GREELEY
Secretary-Manager, West Coast Lumbermen's Association

It has become a truism that modern warfare is largely **war of production.** Behind the military front, the real test of strength is the ability of a warring country to maintain its supply of many different commodities of normal, peacetime production; and to correlate their use for the maximum degree of national economic strength.

One of the first and continuing requisites of warfare in the modern mode is the quick need for troop housing in mass quantities; for all the other forms of shelter that go with the concentration of men and material; and for packaging immense quantities of goods. During the participation of this country in the World War of 1917, the Army and Navy required over 6 billion feet of lumber in the United States. Three billion feet were used directly for troop housing; 2 billion feet for boxes and crates; 750 million feet for shipbuilding; and 500 million feet for miscellaneous military items—gun stocks, artillery wheels, docks, etc.

During its less-than-18-months' operation in France, the American Expeditionary Force required some 600 million feet of timber. The great bulk of this went into cantonments, warehouses and hospitals. Operations at the front required quantities of railroad ties, road plank, heavy plank and duck boards for the dugouts and trenches. The supply bases required piling and heavy timbering for docks and the lumber items used in the enlargement of railroad facilities.

The National Defense program of 1940 has called, to date, for approximately 1½ billion feet of lumber. Close to a billion board feet will be used in constructing the cantonments necessary to bring the men in military training up to approximately one million soldiers. 1500 board feet per soldier is the figure used for permanent barracks; and 800 feet per soldier for tent encampments. The other half billion feet approximately has been required for naval air bases; for the extensive work in the Panama Canal Zone; and for the projects already begun in housing workers at navy yards, aircraft factories and other wartime industries.

The purchases of lumber to date probably represent not more than 40 per cent of the total that will be required to complete the National Defense as now planned. Next to troop housing, the largest single item will be the housing of workers at wartime industries, which is now estimated at a minimum of 75,000 family units. Another large item will be the improvement of municipal and other airports all over the United States. The construction of munitions factories themselves will require considerable quantities of lumber. No estimates have yet been made of what will be needed to equip the far-flung cordon of naval and air bases, which is to be created offshore in the Atlantic and Pacific.

As in the first World War, the great bulk of the lumber required is in the everyday building items—the Dimension, Sheathing, Flooring and Siding, normally manufactured in the largest quantities. It is indeed fortunate that the heaviest needs for National Defense are for these types of lumber freely produced in all forest regions of the United States.

It is interesting to note, however, that —for all the developments in metallurgical craftsmanship and in the assembly-line type of mass production— modern war has need for the technical

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qualities of high-grade and specialized types of lumber. These requirements are constantly changing. We no longer make artillery wheels of wood. The wooden ship is not in the forefront of defense today as it was in 1917. But still wood holds some place in the specialized arts of war. Apparently one of the reasons why England has maintained her fighting air fleets so successfully, against all the odds, is her extensive use of laminated spruce construction, whose parts are cut, shaped and glued up in thousands of little shops spread all over the country, down to one carpenter and his bench. With the uncertainty over continuing supplies of spruce, English laboratories have worked out satisfactory substitutions of Douglas fir in airplane construction, part by part; and Douglas fir airplane stock is becoming an important war item. The American Corps of Engineers, and its contractors, has been combing the Pacific Northwest for the needed quantities of pontoon lumber, of the greatest strength and resiliency our Douglas fir timber can afford. This is used in building emergency bridges, under fire if need be. And the bridge has got to take a 10-ton tank, charging into action at 40 miles an hour. There are substitute schedules in steel bridges; but for all requirements—several types of timber still hold the lead.

Another striking fact in the supply of military needs as we know them today, is the necessity for having substitute materials ready to replace a preferred material, when it becomes short in supply or more essential for some other purpose. As an illustration, some of the emergency additions to aircraft factories in California, designed in steel, have been built with timber framing and trusses because the timber could be had quickly and the delivery of steel would be delayed. The ability of German science to find an "ersatz", or substitute, for many materials lacking within their reach, has been one of the leading factors in military preparedness. The United States must take a leaf out of the same book, in organizing our economy for a long struggle. And it is in this field, no less than in the immediate, first-line requirements, that forest-grown materials can play a very useful role. It is by no means inconceivable, for example, that the present world struggle will again call for the wooden ship.

Let me give a definite example. Largely through the research at the U. S. Forest Products Laboratory, the United States has learned what Germany knew years ago. That, through a combination of plasticizing and pressure, wood can be converted into an extremely dense, tough material, interchangeable with metal for many purposes hitherto undreamed of. One of them is for the fins of airplane propellers. All of which simply points to the obvious lesson that, for National Defense, even more than for peacetime economy, we should **know our wood** and what can be done with it. We need more, and still more, research on the technology of forest-grown materials.

It is not difficult to draw obvious conclusions on the Relation of Forest Production and Use to National Defense. The same characteristics that make forestry and forest-using industriesefficient in times of peace—make them doubly efficient in the stress of national emergency. That is to say: well-established forest practices which maintain growing stock and continuing supplies of raw material; an industry with the capital resources able quickly to enlarge plant facilities for unexpected demands; and a fully-developed wood technology that can fit lumber and other products of the tree into whatever places they may serve for defense, either on the first line or in the reserves.

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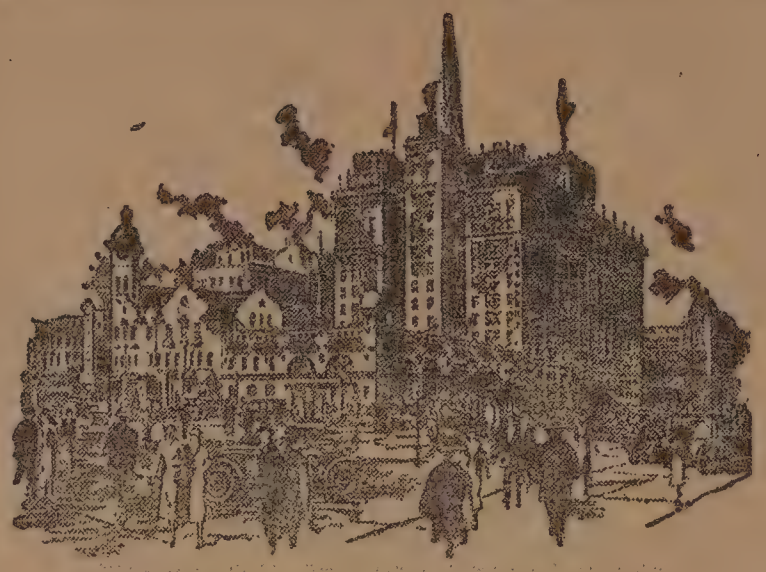

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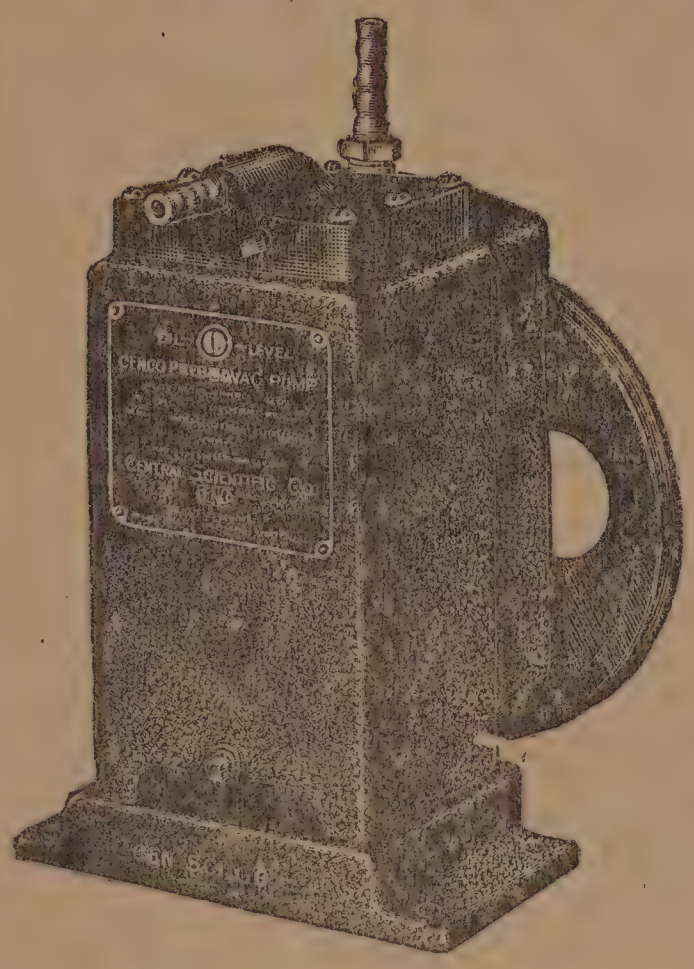

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PACIFIC DIVISION A. A. A. S.

A record attendance at the Pasadena meeting was recorded by the Pacific Division of the A. A. A. S. It was announced that the 1942 meeting would be held during the third week in June at Salt Lake City. The 1943 meeting will probably be held at Corvallis.

Paleoecology of a Montane Peat Deposit Near Lake Wenatchee, Washington[1]

HENRY P. HANSEN
Oregon State College, Corvallis, Oregon

INTRODUCTION

The interpretation of montane post-Pleistocene forest succession by fossil pollen analysis of peat bogs is somewhat complicated by proximity of the deposits to several life zones. The marked differences in elevation of adjacent areas permits the existence of forests representing several climatic provinces within range of pollen dispersal to the accumulating sediments. It also results in the preservation of a larger number of species of pollen from forest trees, thus making interpretations more general. In areas of slight relief subjected to Pleistocene glaciation, forest succession apparently consisted of a gradual transition from the pioneer forests to those that followed. When one type of forest had given way to the changing environment and was replaced by another, its pollen was no longer recorded in the peat to any extent. Montane bogs, however, may record by their pollen the forests of several life zones or climatic provinces. The biota of a life zone may have moved to lower or higher altitudes because of climatic change or other reasons, but it may still be recorded by the pollen of its forest, together with that of other life zones which may have

[1]Presented before the meeting of the Ecological Society of America, Seattle, Washington, June 20, 1940. Published with the approval of the Monographs Publication Committee, Oregon State College, as Research Paper No. 46 of the School of Science, Department of Botany.

migrated into adjacent areas. These factors tend to make the picture of postglacial forest succession less definite, although the proportion of significant tree pollen should be indicative of the nearest and most extensive life zone.

LOCATION AND ORIGIN OF PEAT DEPOSIT

The peat deposit of this study accumulated at the west end of Fish Lake, Chelan County, Washington, on the east slope of the Cascade Mountain Range. The bog lies at an elevation of about 1880 feet above sea level, and its greatest part is in sect. 21, T. 27 N., R. 17 E., on the Chiwaukum, Washington, Quadrangle. It occupies an area of about 500 acres. Lake Wenatchee, which is much larger than Fish Lake, lies about one mile to the southwest. Both of these lakes owe their origin to glaciation. The Wenatchee and Chiwawa glaciers united in the vicinity of Fish Lake just east of Lake Wenatchee, and the combined icebody moved down the Wenatchee Valley for several miles (Russell, 1900). Fish Lake is retained chiefly by lateral and irregular ground moraines left by the Wenatchee Valley glacier. A deep valley fill extends for many miles downstream from the lake, in which the Wenatchee River has intrenched itself in regaining its preglacial gradient. Lateral moraines in this area occur from about 1200 to 1800 feet above the present level of Lake Wenatchee, indicating that the ice was at least 2000 feet thick. The higher ridges were not glaciated and may have been forested during the latter part of glaciation. The chronological correlation of the glaciers on the east slope of the Cascades with the continental ice sheet is not possible with the data now at hand (Antevs, 1929). It seems probable, however, that in general the recession of the two were concurrent, and the peat deposit represents most of postglacial time.

Several intermittent streams feed Fish Lake from the north, but most of its water is probably received from subterranean sources. A single stream drains it into the Wenatchee River a mile to the south. That most of the valleys at higher elevations to the west carried glaciers, is evidenced by U-shaped valleys, hanging glacial troughs, and cirques at the sources of some of the tributaries. The topography in areas adjacent to the bog is very rugged, with many of the peaks and ridges rising to an elevation of 6000 feet or more. Glacier Peak, about 27 miles northwest, attains an elevation of 10436 feet, and Mt. Stuart, the same distance southwest, has an elevation of 9470 feet. Both mountains support living glaciers.

FORESTS IN ADJACENT AREAS

The bog is located within and near the eastern edge of the Canadian life zone, although most of Fish Lake is in the Arid Transition (timbered) zone (Piper, 1906). The rapid rise in elevation immediately to the northwest causes the latter zone to grade abruptly into the Canadian zone. As a high ridge a few miles farther east also supports the Canadian zone, the timbered Transition zone extends up the Wenatchee River valley as a peninsula into the Canadian zone. At higher elevations, in all directions except the southeast, the Canadian zone grades into the Hudsonian zone, and the higher peaks and ridges rise above timberline into the Alpine zone. At much lower elevations near the mouth of the Wenatchee River, the timbered Transition zone grades into the Upper Sonoran in the Columbia River valley. There are three life zones within 10 miles and five life zones within 25 miles of the bog. It is probably within range of pollen dispersal from all of these vegetation provinces, but the Canadian and Transition (timbered) zones comprise the largest part of the area within a 25 mile radius.

The Canadian life zone in the state of Washington is not well defined, but

western white pine (*Pinus monticola*) is probably more restricted to and representative of this zone than any other tree (Piper, 1906). On the eastern slope of the Cascades other trees present, but not confined to this zone, include Douglas fir (*Pseudotsuga taxifolia*), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), Engelmann spruce (*Picea engelmanni*), western red cedar (*Thuja plicata*), lodgepole pine (*Pinus contorta*), lowland white fir (*Abies grandis*), silver fir (*A. amabilis*), and noble fir (*A. nobilis*). The latter two are not common on the east slope of the Cascades. Lodgepole pine is chiefly a disclimax species and may invade areas that have been disturbed by lumbering and fire.

The timbered Transition zone is characterized chiefly by western yellow pine (*Pinus ponderosa*), which usually exists in open pure stands because of its intolerance for shade. Other trees in order of their importance are Douglas fir, western larch, lodgepole pine, western hemlock, western red cedar, and white fir. The latter two occur chiefly on protected sites near stream courses. Broadleaf species which thrive locally on favorable sites but are not common include cottonwood (*Populus trichocarpa*), mountain birch (*Betula fontinalis*), mountain alder (*Alnus tenuifolia*), late alder (*A. sitchensis*), and several species of willows. These species are not necessarily confined to this zone.

The Hudsonian zone lying just above the Canadian, supports sparse forests of subalpine fir (*Abies lasiocarpa*), mountain hemlock (*Tsuga mertensiana*), white bark pine (*Pinus albicaulis*), lodgepole pine, Alaska cedar (*Chamaecyparis nootkatensis*), and alpine larch (*Larix lyallii*). Near timberline the trees become prostrate and assume the characteristic Krummholz form. Reproduction often occurs by layering because of the adverse conditions for seedling development and the failure of the trees to produce seed during the short growing season. The amount of pollen produced by these forests is probably relatively small, but some pollen apparently drifts to lower elevations, as is evinced by its presence in the bog. It is to be noted that lodgepole pine occurs in all three forested life zones, and the presence of its pollen in the peat may not be indicative of forest succession, but rather of its adaptability and disclimax status.

Clements' classification of the major North American vegetation climaxes places the area in which the bog lies in the larch-pine association of the Coast Forest (Weaver and Clements, 1938). This forest lies between the subalpine and grassland formations and includes most of the Canadian and timbered Transition zones. The larch-pine forest is a transition type between the Cedar-hemlock formation of the coast forest and the montane forest of the Rocky Mountains. It reaches its maximum development in northern Idaho. Zon (1924) includes the zone of the bog in the yellow pine-Douglas fir forest, with the spruce-fir forest adjacent immediately above, and the bunch-grass prairie adjoining below. The yellow pine-Douglas fir forest includes all of the timbered Transition zone and a large part of the Canadian zone, and the spruce-fir forest includes the remainder of the Canadian and all of the Hudsonian zone according to the latter classification.

The ruggedness and great relief of the surrounding terrain, with its accompanying diversity of slope, exposure, soil, and climate, permit the existence of many localized associations, faciations, and consociations near the bog. This range of environmental factors and its expression by the forest cover may perhaps best be portrayed by the number of forest types within a small radius to the bog. The peat de-

posit lies approximately in the center of the township, which includes eight distinct forest types (Forest type map, 1936). The greater part of the township is covered with yellow pine of four types, including small and large trees and ranging in volume from 50 to 80 per cent. This is to be expected, because two-thirds of the township lies within the Transition zone. Other more localized types include Douglas fir, both large and small, comprising 60 per cent of the stand by volume; lodgepole pine, comprising 50 per cent; and a pine mixture consisting of yellow and white pine, western larch, Douglas fir, and white fir. Adjoining townships to the north and west are covered largely with upper-slope types composed of subalpine, noble, and lovely fir, mountain and western hemlock, western larch, Douglas fir, Engelmann spruce, and white and lodgepole pines. Subalpine types consisting of Alaska cedar, mountain hemlock, alpine larch, and white bark pine also exist, but these are sparsely forested. The forests and their component species have been discussed here somewhat in detail in order to show the large number of conifers present and their distribution in relation to the bog, as well as the sources of the many species of pollen in the peat.

The mean annual precipitation recorded a few miles west of the bog, in the Canadian zone, at an elevation of 1990 feet is about 38 inches. Less than 15 per cent of this occurs during the growing season. Thornthwaite (1931) in his classification of the climates of North America designates this area as having a humid microthermal climate, with adequate precipitation at all seasons. His description of the seasonal distribution of precipitation, however, does not seem to be correct in view of the dearth of rainfall during the growing months, but as his classification is general, it does not include local deviations within the larger climatic provinces. To correlate the climatic provinces of Thornthwaite with Clements' climax formations, the larch-pine forest coincides in general with the humid microthermal climatic zone along the eastern flank of the Cascade Range. The timbered Transition zone is partly included in this climatic province, and the adjoining one is designated as subhumid microthermal, with a deficiency of precipitation at all seasons. There necessarily must be a gradual transition from one climatic province to the next, and as the bog is near the line of junction, it seems reasonable to consider areas of the same elevation near the bog as having an inadequate summer precipitation. It is realized that the interplay of temperature and precipitation brings about a physiological compromise and is an index to the amount of water available to the plant.

FLORA ON THE BOG

A marginal ditch surrounding the bog retains water during most of the year. This zone supports a rather nondescript community of swamp plants including *Cyperus inflexus, Juncus regelii, Typha latifolia, Sparganium eurycarpum, Potamogeton alpinus, Lysichitum americanum, Bidens cernua, Equisetum fluviatile, Carex* spp., *Salix* spp., *Alnus tenuifolia, Spiraea menziesii,* and *Cornus stolonifera.* At the west end of the lake several stages of hydrarch succession are present, including a floating plant hydrosere characterized chiefly by yellow pond lily (*Nymphozanthus polysepala*), and followed on the bog by poorly defined zones of cattail, bulrush, sedge, and rush. Most of the surface of the bog is in the sedge-meadow stage at present, but inundation during part of the year allows the persistence of many hydrophytic plants. The more common plants are several species of sedge, *Eleocharis acicularis, Eriophorum gracile, Viola palustris, Bidens cernua, Epilobium alpinum,*

Potentilla palustris, Menyanthes trifoliata, Drosera rotundifolia, Spiraea menziesii, and a shrubby willow. Widely scattered patches of *Sphagnum* sp. are present, but *Drepanocladus aduncus*[2] seems to be the most abundant and widely spread moss. A single dead specimen of lodgepole pine was noted near the margin. The bog apparently never existed in the Sphagnum-ericad stage, as is evidenced by the scarcity of sphagnum leaves and the entire absence of ericad pollen in the peat.

METHODS AND TECHNIQUE

Peat samples were obtained at quarter-meter intervals with a Hiller peat sampler. The thickness of the pollen-bearing sediments in the area of sampling is 8.5 meters. The lowest three-quarter meter consists of gray sand, underlain with coarser sand and gravel of such compactness as to prevent penetration with the peat sampler. It was not possible to secure samples at the 7.5 and 7.25 meter levels because of the liquid nature of the sediments. Sandy silt at the next three higher levels grades into gray limnic peat at 6.5 and 6.25 meters. An olive-green, colloidal limnic peat is present from 6 to 3 meters, which grades into brown fibrous sedge peat present to the surface. Volcanic ash crystals occur from 3.75 to 3.25 meters but are most abundant at 3.5 meters. Volcanic ash is present usually as a single layer in peat and other lake sediments in the Pacific Northwest (Rigg and Richardson, 1938, Hansen 1938, 1939a, 1939b, 1939c, 1940b, 1941a, 1941b, 1941c). A bog located near New Westminster, British Columbia, likewise shows no definite stratum of ash, but pollen analysis revealed the presence of crystals dispersed throughout a half meter of peat (Hansen, 1940a). In other post Pleistocene sediments of the Pacific Northwest which lack a layer of ash, the presence of crystals may be disclosed upon microscopic examination. The presence of an ash stratum in lake sediments in the lower Willamette Valley of Oregon, and the occurrence of pumice layers in peat deposits on the east slope of the Cascade Range in Oregon suggests that there may have been several sources for these deposits. Those described in Washington may have come from Glacier Peak in the northern part of the state,[3] while the pumice in bogs lying north and east of Crater Lake may have come from the eruption of Mt. Mazama which apparently occurred long after the maximum of Pleistocene glaciation (Williams, 1939).

In preparation for study, about 2 cc. of peat or pollen-bearing sediments were boiled 15 minutes in a weak solution of potassium hydrate with gentian violet stain, strained through cheesecloth, washed several times with water, and mounted in glycerin jelly. Exactly 200 significant pollen grains were identified from each level. The nonsignificant pollen was also identified but was not used in the computation of percentages (table 1). The method used in the identification of Pacific Northwest fossil conifer pollen has been described in recent papers (Hansen, 1940b, 1941a, 1941b). Fossil pollen is identified by measuring the cell or grain and assigning it to that species within whose size-range it falls. If the dimensions are within the limits of overlap of the size-ranges of smaller or larger pollen of other species it is discarded as an unknown and listed under its generic name (table 1). The number of these pollen grains is not used in computing the percentages for the pollen profiles. It seems impossible to separate the pollen of species whose size-ranges are within those of larger or smaller species or that of a single species. In this paper pollen designated as that of *Pinus*

[2]Identified by Miss Clara Chapman, St. Helens Hall, Portland, Oregon.
[3]Information from Dr. A. C. Waters, Department of Geology, Stanford University.

TABLE 1. PERCENTAGES OF FOSSIL POLLEN

Depth in meters	8.5	8.25	8.0	7.75	7.0	6.75	6.5	6.25	6.0	5.75	5.5	5.25	5.0	4.75	4.5	4.25	4.0	3.75[1]	3.5[1]	3.25[1]	3.0	2.75	2.5	2.25	2.0	1.75	1.5	1.25	1.0	0.75	0.50	0.25	0.0
Pinus contorta	19	17	6	15	14	11	0	5	5	6	7	10	9	9	7	6	7	8	9	9	10	14.5	11	9	10	9	5	8	10	11	10.5	9	15
P. monticola	12.5	20	24	28	35	38	35	38	48	50	46	44	36	40	42	43	39	40	40	40	39	38	29	30	29	36	47	42	28	18	18	20	13
P. ponderosa	36	36	32	24	10	12	14.5	10	7	7	6	8	9	13	13	16	12	18	18	15	17.5	27	34	36	32	27	20	19	22	35	35	35	37
Pseudotsuga taxifolia	6	5	8	8	11.5	10	14	13	11	11	13	13	9.5	11	9	5	10.5	9	10	9	8	2	6	4.5	5	3.5	6	8	9	6	3	6	9
Tsuga heterophylla	7	7	6	11	8	8	11	12	12	6	11.5	5	12	12	10	10	7.5	6	11	11	7.5	6.5	3	4	4.5	7	8.5	4.5	10	12	15	9	10
T. mertensiana	1	4	2	0.5	3	5.5	2	6	2.5	6	2	2	7	3.5	4	2	6.5	2.5	1.5	0.5	3	1	1.5		3	3		3	2.5		3	1.5	2.5
Picea engelmanni	5	1	2	1.5	5	2	1.5	2	1.5	2.5	2	1.5	2		2	1.5	0.5	1	0.5	1	2.5	1.5	1	0.5	1	2.5		1.5	2	2	1.5	1	2
Abies grandis	8	5	5	5	3.5	6	6	7	4.5	5	6	5	6.5	5	7	3.5	9	7	2	3.5	5	3	5	3	4	3.5	9.5	5.5	9	7.5	8.5	9	5.5
A. lasiocarpa	5	2	3	3	7	4	2	4	1	3	1.5	2.5	3.5	3	2	6	2.5	3	2	2.5	1	2.5	0.5	3	2	1.5	1	3	2.5	2.5	1.5	2	2
A. nobilis		2	2	3	2	3.5	2	2.5	2	2.5	1.5	4.5	2.5	2.5	2.5	4	1	3	1	3	2	1.5	2.5	2.5	1.5	2	2.5	2	3	2	2	5	2.5
Larix occidentalis		0.5					0.5					2	1	1	1	1	1.5	2	4	4	4.5	2	5.5	6.5	7	4		3	2	2	0.5	1	1.5
Pinus spp.[2]	12	17	19	13	18	21	11	23	9	11	13	15	12	13	14	18	19	21	17	8	12	13	15	18	22	21	17	16	17	22	19	16	12
Abies spp.[2]	2	1	1	3	5	3	2	1		2		5	6	3	2	1	3	4	1			1	1	2	2	1	5	3	1	2	3	5	2
Gramineae	0.5	0.5		1	0.5		0.5	0.5	5.5		3	2.5	2		0.5	1.5	3	0.5	1	1.5		0.5		1	0.5	1				1.5	1	1.5	
Compositae					0.5		1									0.5							0.5		0.5		0.5	0.5		0.5	0.5		
Chenopod-Amaranth										1	0.5												0.5										
Alnus[3]	10	7	16	17	12	7	20	16	18	10	22	14	14	20	23	20	12	20	8	5	23	10	4	12	15		1	1	2	9	14	2	9
Betula[3]						1							1	1		1														1			1
Acer[3]	1		1	2		1				1	1	3		2		1	2	1	1	1		1	1					25	1	2	3	6	1
Salix[3]		3	2	1	3		2	1	2				1		4	12	8	3	1	3	4	1	1	1				1	1	3			4
Cyperaceae[3]		2		2	2		2				1		1								14	36	70	31	16		60	23	70	53	34	9	11
Nymphozanthus polysepala[3]																									1								
Typha latifolia[3]	1	1	1	1												1	1	1		1	2	1		1	1		1	1	3	2	3		1

[1]Volcanic ash crystals.
[2]Number of discarded pollen grains of **Pinus** and **Abies**, not computed in percentages.
[3]Number of pollen grains, not computed in the percentages.

ponderosa and *P. monticola* may include some of *P. albicaulis* whose pollen size-range is within that of the first. Likewise, pollen identified as *Abies grandis* and *A. nobilis* may include some of *A. amabilis,* while *Larix occidentalis* may constitute some of *L. lyallii.* Pollen of *Tsuga heterophylla* may be readily separated from that of *T. mertensiana* because of the presence of bladders on the pollen of the latter. Pollen of *Pseudotsuga taxifolia* is distinct, and offers no difficulties in its separation. The author realizes that there may be some error in this procedure, but it is believed that this method of pollen identification involves no more error than is present in the whole problem of pollen statistics.

FOREST SUCCESSION

The forests existing in areas adjacent to the bog when the earliest pollen-bearing sediments were deposited consisted chiefly of western yellow, lodgepole, and white pine, with a preponderance of the first (Fig. 1). They recorded 36, 19, and 12.5 per cent of the significant pollen respectively. Pollen of other conifers present are Douglas fir, western and mountain hemlock, Engelmann spruce, and lowland white and noble fir (table 1). As previously suggested, it is possible that forests existed on adjacent unglaciated ridges during the latter part of the glacial period, and that forest succession had advanced beyond the pioneer stage at the time the lowest pollen-bearing sediments were deposited. This is further suggested by the low proportion of lodgepole pine and the presence of some Douglas fir and western hemlock pollen in the bottom level. In most of the bogs analyzed to date in the Pacific Northwest, lodgepole pine was the dominant pioneer postglacial invader and was recorded by its pollen from 34 to 78 per cent in the lower levels (Hansen, 1938, 1939a, 1939b, 1940a, 1940b, 1941a). These bogs lie within the glaciated region and the initial forest invasion as recorded probably occurred on primary denuded terrain. In a bog within, but nearer the edge of the timbered Transition zone in the same general region, western yellow pine is likewise recorded by the highest proportion of pollen in the lowest level (Hansen, 1939c). This bog apparently was formed in a landslide depression in an unglaciated area, and it may not record all of postglacial forest succession. In Oregon bogs located well beyond the limits of Pleistocene glaciation, lodgepole pine is similarly recorded by low proportions of pollen in the lowest levels (Hansen, 1941b, 1941e). This substantiates the theory that established forests were in existence during the glacial period and at the time the lowest sediments were deposited. Although lodgepole pine is abundant along the Oregon Coast, bogs in this region record extremely low proportions of this species at the bottom as well as throughout their entire profiles.

If the unglaciated ridges adjacent to the bog of this study were not forested during the glacial period, there is an alternative explanation for the low representation of lodgepole pine in the lower levels. The earliest pollen-bearing sediments may not have been deposited immediately upon the recession of the ice, and the forest succession may have already advanced beyond a pioneer lodgepole pine-invasion. Yellow pine decreases sharply from 36 per cent at the lower two levels to 10 per cent at 7 meters, and then declines more gradually to 6 per cent at 5.5 meters, its lowest proportion in its pollen profile. White pine rapidly increases from 12.5 per cent at the lowest level to 50 per cent at 5.75 meters, from which point it gradually declines to 29 per cent at 2.5 meters. Concurrently, yellow pine increases from its lowest proportion of 6 per cent at 5.5 meters to 36 per cent at 2.25, where it supersedes

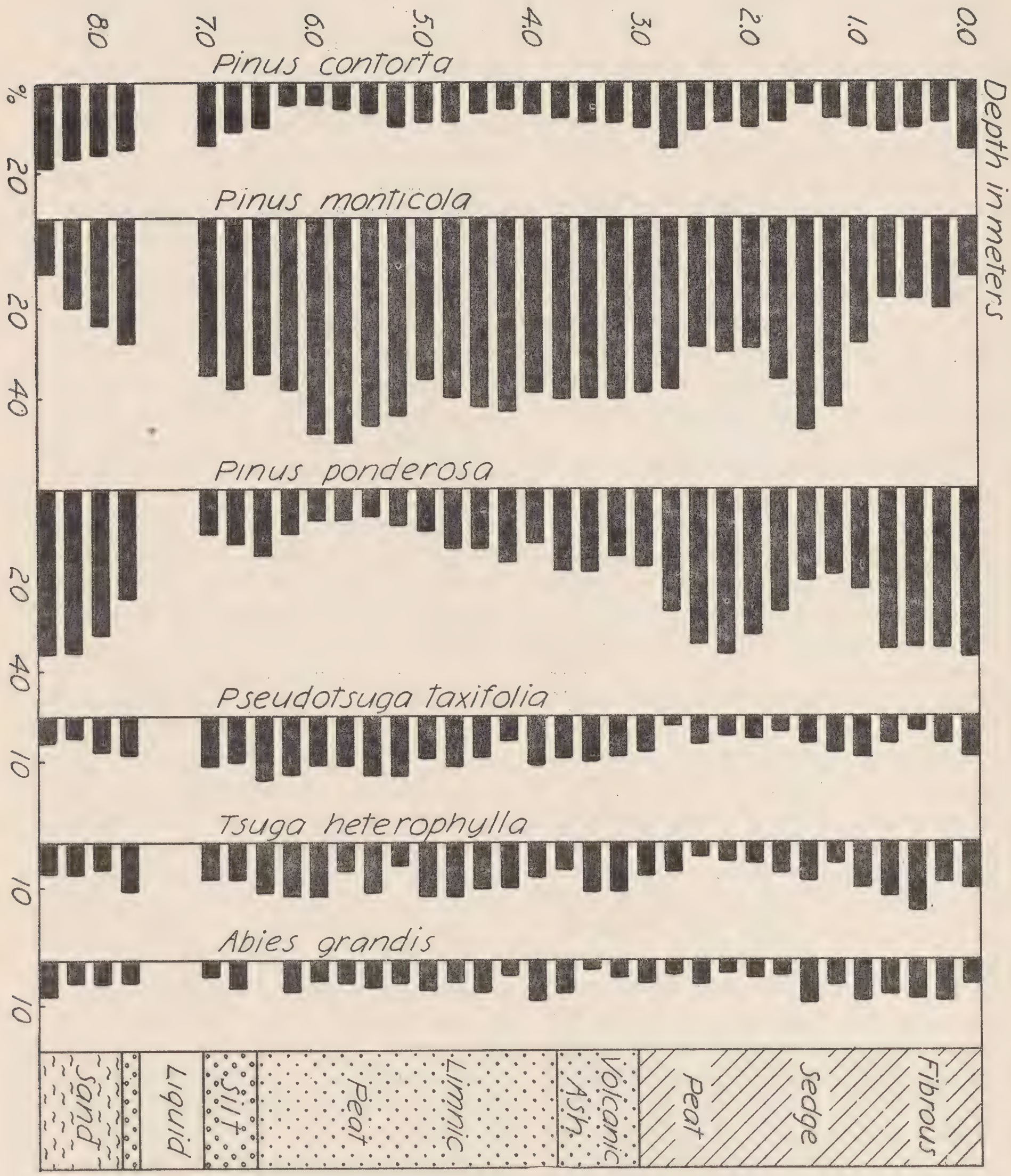

FIGURE 1. Pollen Profiles of Fish Lake bog.

white pine. The latter again shows a sharp increase to 47 per cent at 1.5 meters, and then makes a final decrease to 13 per cent at the surface. Conversely, yellow pine diminishes to 19 per cent at 1.25 meters and then records a final increase to 37 per cent at the surface. Lodgepole pine gradually declines to 5 per cent at 6.25 meters from its highest proportion at the bottom, and then fluctuates between this and 15 per cent at the surface. It is to be noted that the final percentages of lodgepole, white, and yellow pine approximate those at the bottom level. The highest proportion of pollen recorded throughout the profile is that of white pine with 50 per cent at 5.75 meters (fig. 1).

Douglas fir, western hemlock, and lowland white fir are the best represented of the other conifers by their pollen profiles. These species show slight fluctuations from bottom to top, and do not seem to denote any modification of the forest succession as is suggested by the pollen profiles of yellow, white, and lodgepole pine. Douglas fir fluctuates from 2 to 14, western hemlock from 3 to 15, and lowland white fir from 2 to 9.5 per cent (table 1). In the lower levels of other bogs that have been analyzed in the Pacific Northwest, Douglas fir and hemlock are recorded by their pollen only slightly or not at all. This fact suggests that they do not appear with the pioneer invaders in early postglacial forest succession in the glaciated region. Either no seed-bearing specimens existed sufficiently close to the ice-front to make possible an initial invasion, the environmental conditions were not favorable, or they could not compete with the more adaptable and aggressive lodgepole pine. When the environmental conditions left in the wake of the glacier were sufficiently ameliorated, these species were able to enter. In the Puget Lowland they gradually replaced the earlier forests and competed with each other for predominance (Hansen, 1938, 1940a, 1941a). In the Fish Lake bog the presence of their pollen in the lowest level supports the theory that the pioneer postglacial forest of this area may have not been recorded even in the earliest pollen-bearing sediments.

The pollen of Engelmann spruce, alpine and noble fir, mountain hemlock, and larch is present at most horizons, but the maximum attained by any one is only 7 per cent. With the exception of western larch, pollen of these species probably drifted down from the Canadian and Hudsonian zone forests at higher altitudes, or possibly was carried into the lake by incoming streams rising at much higher elevations. Their slightly higher proportions in the lower half of the profile, however, suggest that these subalpine species existed at lower altitudes during this time, which reflects a cooler climate. It is also possible that the pollen of larch includes some of alpine larch, and that of western white pine a goodly proportion of white bark pine, which would further substantiate the latter interpretation. Pollen analysis of subalpine bogs may help to solve this problem by showing to what extent subalpine species is recorded in such peat deposits.

Alder is represented at most horizons. A maximum of 23 pollen grains is recorded at 4.5 and 3 meters. Other broadleaf species are represented by sporadic occurrences of their pollen and include mountain birch, vine, largeleaf, and dwarf maple, and willow (table 1). The increase in sedge pollen in the upper levels is correlative with the gradation of limnic peat into fibrous peat in the upper levels.

CLIMATIC CONSIDERATIONS

In recent papers the author has expressed the belief and attempted to show that climate has not been the ma-

jor, if even an important factor, in the control of post-Pleistocene forest succession in the Pacific Northwest. This is perhaps more true west of the Cascade Range than to the east. The successional relationships of the many coniferous species seem to be largely controlled by their reaction upon the environment and their coaction with one another as well as other species of plants and animals. This is evinced by the subclimax status of Douglas fir in the Cedar-hemlock association of the coast forest, and of western white pine in the Hemlock-cedar-lowland white fir formation in northern Idaho (Huberman, 1935). Fire is also an important element in altering the environmental conditions, changing the forest composition and course of normal forest succession, allowing invasion by disclimax species, permitting the persistence of subclimax seres, and inhibiting the culmination of the climax formation. Prehistoric fires doubtless played an important role in interrupting postglacial forest succession. This generalization is without proof in the area of this study, but pollen analysis and the presence of several charred-peat layers in a bog in the Coast Range of Oregon shows that fire has apparently been responsible for the persistence of Douglas fir as the predominant species in this area during the post-Pleistocene (Hansen, 1941b). During the summer of 1939, the United States Forest Service reported 1273 forest fires in Oregon and Washington as having been caused by lightning. There seems to be no reason to believe that fires caused in this way were less common in the past. An example of how the results of fire might be reflected in the pollen record of montane forests is the burning of an extensive area within a single life zone or forest type. The pollen from these forests would be reduced in quantity, while that from forests in adjoining unburned areas would remain the same. The latter, however, would record a higher proportion and thus falsely denote an increment in the species of that zone. This would probably be more true in rugged montane regions with several life zones than in regions with slight relief and extensive expanses of a single association.

Insect depredations on the forests are an important biotic factor which materially influence the course of forest succession. The damage of insects to the forests is less precipitate and spectacular than that caused by fire, but it may be of tremendous magnitude. In the western forests the pines have the most insect enemies, and of these the bark beetles are the most numerous and destructive (Keen, 1939). They destroy more standing timber than all other insects combined. Pine, spruce, fir, and hemlock are most severely subjected to insect damage in the order named, but larch is comparatively free from insect pests. Their differences in degree of susceptibility to insect attack cause the normal forest succession toward a climax to be radically upset and deferred, or perhaps inhibited entirely. In western white pine and lodgepole pine forests of the northern Rocky Mountain region, bark beetles so affect the proportion of species as to convert stands to entirely different composition (Keen, 1939). In Yosemite National Park, lodgepole pine stands completely destroyed by bark beetles have been succeeded by forests of hemlock and fir. In other areas bark beetle epidemics in mixed stands of yellow pine and white fir have killed all of the pine and changed the stand into pure fir. Insect depredations in prehistoric times probably have been as common and effective as today, and the postglacial forest succession doubtless was appreciably influenced by this factor. Fungal disease also perhaps played a somewhat parallel role in altering postglacial forest succession.

Snowslides and landslides are additional nonclimatic factors which may have disrupted and modified postglacial forest succession. This is especially true in rugged montane regions, and one may see large denuded areas where snowslides have removed much of the forest. Landslides are also common in areas of tilted rock strata and on talus slopes at the base of columnar basalt cliffs. The accumulated soil and vegetative cover is removed, and plant succession is interrupted and must begin anew. Soil formation is modified and controlled in its many aspects by the vegetative cover. The type, texture, structure, and depth of the soil, and the parent rock from which it is derived, however, have a profound effect upon the course and rate of plant succession. Soil erosion in a topographically young montane region is rapid. Mature soil profiles consequently develop slowly, and a soil climax may not be attained until a region has been planed down and the rate of erosion reduced. Fire also may augment the rate of erosion. Piper (1906) stated that western yellow pine tends to avoid soils that have been derived from basalt, and favors the granitic types. This is one example of the many edaphic factors regulating forest succession and determining the climax in the area of this study, because the basaltic strata of the Columbia Plateau abut against the eastern slope of the Cascade Range in this region.

White and yellow pine seem to be the best climatic indicators of successional and climatic trends in this study, from the standpoint of both their present ranges and of recorded pollen. They are the only species showing sufficient fluctuation upon which to base an interpretation of climatic trends, and they are more distinct and restricted in their respective ranges than the other species concerned. As previously stated white pine is generally confined to the Canadian zone except where favorable localized areas may support a few isolated trees. Yellow pine is largely limited to the timbered Transition zone, but also occurs in adjacent zones where local conditions enable it to thrive. The present range of white pine indicates that it thrives best under moister and cooler conditions than does yellow pine, and that it is more tolerant of shade. White pine usually exists as a subclimax species, because it is less tolerant of shade than the climax dominants in the area where it makes its maximum development (Larsen, 1929). Yellow pine usually occurs in pure stands, and it is the climax tree within the range of its best growth. It seems to re-enter without a disclimax or subclimax sere after having been removed by fire or cutting (Shantz and Zon, 1924). In its present range the annual precipitation is apparently too low to permit competition and replacement by other species. It seems reasonable to infer from these facts that an increase in yellow pine pollen marks a warming and drying climate, while an increase in white pine pollen denotes a cooler and moister climate in the area of this study. The small fluctuation of the other conifers is significant, because it means that yellow and white pine vary conversely with respect to each other. This fact suggests that their fluctuation may be more a direct result of climate than of normal forest succession controlled largely by the biotic, edaphic, and physiographic factors.

There are four general trends of increase and decrease for yellow and white pine; and increase of one being concurrent with a decrease of the other and vice versa (fig. 1). Climatically these fluctuations suggest a long initial period of increasing coolness and moisture, followed by a warmer and dryer period of perhaps equal length. A third and shorter period of increased coolness and humidity is marked by

the increase and decrease of white and yellow pine respectively. This was succeeded by a final dryer and warmer period, which has existed to the present. The third period, however, was brief and poorly defined, and the fluctuation in the proportion of pollen may be the result of forest succession interrupted by factors other than climate. If this is true, the first period was followed by one of warming and drying to a maximum which has persisted to the present. This alternative interpretation would be more correlative with that of the previously mentioned bog within the timbered Transition zone and one in northern Washington (Hansen, 1939c, 1940b). The early, gradual increment in white pine suggests a downward movement of the Canadian to replace the timbered Transition zone, which apparently existed near the bog at the time the lowest pollen-bearing sediments were deposited. The reverse of this sequence of events then followed, and upon the basis of the proportion of pollen in the highest horizon, the composition of the present forest is similar to that which existed at the beginning of its record. The limited record and fluctuation of the Hudsonian zone species suggest that the climate did not vary sufficiently to cause their marked increase or decrease in areas adjacent to the bog. As previously stated, however, it is possible that the pollen of larch and pine may include more or less of the subalpine species of the same genera. If this is true it would tend to indicate even a greater degree of cooling than suggested by the maximum proportions of western white pine pollen. An increase in moisture probably would cause an increase in white pine at the expense of yellow pine without necessarily a decrease in temperature. White pine would then be able to compete with yellow pine because of its advantage of greater tolerance for shade.

SUMMARY

At least eleven species of conifers are recorded by their pollen in a montane peat deposit, located within but on the edge of the Canadian life zone on the east slope of the Cascade Range in Washington. The time of origin of the pollen-bearing sediments is indefinite, but they probably represent most of post-Pleistocene time. The stage of forest succession as recorded by pollen suggests that some postglacial time had elapsed when the initial pollen-bearing stratum was deposited, or that adjacent ridges and highlands were forested during the latter part of the glacial epoch.

Several life zones and climatic provinces, represented by many distinct forest types existing within a small area around the bog, tend to complicate the interpretation of forest succession and climatic trends. The major trends of succession and movement of life zones seem to be best indicated by the pollen profiles of western yellow and western white pine. The limited representation and fluctuation of other species of the Transition, Canadian, and Hudsonian zones minimizes their importance as indicators.

The earliest forests recorded consisted chiefly of yellow, white, and lodgepole pine, with a preponderance of the first. A gradual and constant increase in white pine suggests a cooling and humidifying of the climate, succeeded by a final warmer and dryer period as evidenced by the increase of yellow pine and decrease of white pine. A minor fluctuation in the upper levels may be a result of factors controlling forest succession other than climate. The composition of the present forests is similar to the first forests recorded, as based upon the interpretation of pollen analysis. The author has pointed out some nonclimatic factors that may have influenced forest succession.

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The Role of Foresters in the Defense Program

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Due to the newness of the profession of forestry in the United States, the role of foresters in wartime has not been extensive. The first serious proposal in this regard was made during the Mexican campaign of 1916 when many foresters were interested in forming a hard-riding, straight-shooting troop of cavalry composed of men capable of taking care of themselves in the open and with the physical stamina necessary for such work. Due to the shortness of the Mexican campaign and to the growing official desire for a change in the volunteer system as used by the American Army, this troop did not materialize.

The entry of the United States into the World War soon brought about the formation of the 10th Engineers, composed essentially of foresters and lumbermen. This regiment was followed by the 20th, the 41st, the 42nd and the 43rd Engineers and seven service battalions. This entire group was shortly welded into the 20th Engineers—a regiment which was the largest in the American Army. In November of 1918 it had a personnel of 20,000 officers and men with plans under way of increasing its personnel to 50,000. It had 282 sawmills and the necessary logging and transportation equipment to supply logs to these mills. The regiment produced in October 1918 over 50 million feet of lumber, 80,000 cords of fuel and enough ties to build a railroad from the Lake States to the Gulf.

This regiment was an important unit in the A. E. F. due to the urgent demands for wood products by the troops in France. Because of the excessive

demands for transportation should the Army be supplied with wood from America, the regiment was sent to France to cut in the forests of that country.

The American forester was an essential element of the 20th Engineers because of the requirement of the French that their forests be cut only under good forestry practices. The trained forester in the twentieth engineers in France also demonstrated his adaptability as a lumberman in operating small mills and logging units under active wartime conditions.

The Spruce Production Division, which grew out of the 686 million dollar airplane program, is another illustration of the prospective field of activity of the professional forester during war time. This division of the Signal Corps was organized in November 1917 to supply the army adequately with spruce for airplanes. It built, in 45 days, a spruce cut-up plant in Vancouver, Washington, a plant with ten head saws manned by a crew of 4000 and operating 24 hours a day. The Spruce Division reduced by 75% the freight cars necessary to ship lumber East within the first four months of its operation. The Division made the necessary reconnaissance to locate desirable stands of airplane spruce and had nearly completed the opening up of two large tracts, one in Lincoln County, Oregon, and the other on the Olympic Peninsula in Washington. It had, through the stimulation of private endeavor and the riving of spruce, reached a spruce production of 5 million feet per month by the end of the War.

Perhaps the most outstanding accomplishment of the Spruce Division was its development of the Loyal Legion of Loggers and Lumbermen, as a means of combating the I. W. W. strike which was paralyzing the lumber industry on the West Coast. This organization, unique in the labor field, was so successful that it continued until the New Deal labor legislation made it necessary to change its form of organization. At the end of the War the 4-L organization had a membership of over 80,000 civilian timber workers. In the Spruce Division itself was an added 5,000 soldiers actively engaged in the production of spruce for airplanes.

A different type of contribution of the forester in the first world war lay in the technical use of wood. The increased demands for airplane stock for gun stocks, for shuttle blocks, for wagons, for wooden ships and for other uses brought an acute shortage for certain types of well-seasoned lumber. The wood technologist helped solve this problem by suggesting suitable substitute woods and by developing better and faster drying techniques. In this manner the War gave an impetus to scientific dry kilning of lumber that has brought about a boon of enormous value to peace-time lumbering.

This hasty and superficial survey of the past has been made merely to give some inkling of the specialized form of service which foresters can render during war time. It will be noted that the past gives the following suggestions:

1. That foresters are peculiarly adapted to certain types of army activities.

2. That troops in the field require large amounts of various wood products, the supplying of which may be one important field of service of foresters.

3. That the synchronized direction of the great wood products industry toward war aims represents another possible field of service for foresters.

4. That scientific knowledge and research in wood products may make a valuable contribution to the success of American arms during a war.

Insofar as the past may not be an accurate indicator of the future, it may be well to glance for a moment at war

as an institution in order to see if changes made in the art of war will bring about changes in the prospective services of foresters in a defense program.

The most noticeable thing about war is its enormous change from the objectives of peace-time civilization. Peace-time activities have as their major objective the raising of the standard of living of the individual. The emphasis is upon the use of the products of cooperative endeavor based on the golden rule or similar philosophy. War, on the other hand, emphasizes destruction and the agents of destruction. Lives and property values are expended in the hope that an even greater loss in lives and property will be the lot of the enemy. War, therefore, always reduces the average standard of living for the peoples involved—at least for those on the losing side.

The efficient prosecution of a war requires that the man power and raw resources of the nation be directed toward different products than is true in peace time. Modern warfare requires, for instance, that the maximum amount of the available metal be used for war materials. War planes take precedence over commercial planes, and bullets become a better use of iron than do electric refrigerators. At the same time war places a premium on temporary construction. Thus the French found it impractical to replace masonry bridges and viaducts during the first World War. In the early stages of the War, the French used men and materials in making substantial repairs only to find that the Germans would wait until the structure was completed to train their cannons thereon. It followed that low, rough wooden bridges not only allowed the necessary traffic to cross the stream in question, that such bridges could be built with fewer men and materials, but that the Germans found it too expensive to expend the necessary artillery ammunition to destroy them except under active battle conditions. This example, which is typical of a general condition, illustrates why wood, because of its flexibility and workability, is a very important war material. It also illustrates that peace-time standards of quality must be discarded in favor of standards set up in accordance with war objectives.

War not only redirects the economic activity of a nation but it also increases the speed of the flow of raw materials to consumer goods. Bullets are expended rapidly in enormous quantities. Machinery in the form of tanks, guns, airplanes, autos and the like are used heavily under the most severe conditions, thereby requiring a rapid rate of replacement. Efforts to overpower the enemy bring about a rapid increase in war materials and supply. The obvious result is that many men must be changed from their peace-time work in order to develop and maintain the large and rapid flow of raw resources to war materials.

War, it seems, is no respecter of peace-time procedures and traditions. It places a premium on change and demands men capable of changing rapidly. The slow methodical master craftsman often cannot adapt himself to the rapid changes made during war time. On the other hand, the man with vision, the man who can see readily a more effective and efficient means of reaching the desired objective is greatly in demand. War demands that the job be done in a hurry, costs are secondary, the market outlet is assured, change is the order of the day, hence the man with ideas finds many of the peace-time factors of repression removed. Sound thinking and aggressive action bring about solutions to the problems. The right type of man finds freedom of action and accountability only for results. If the battle is won, few ques-

tions are asked as to the ways and means employed.

Foresters, because of their characteristics and type of work, should fit in well in a war program. Physically they are used to hard work away from the softening and easy life of the modern office worker. He therefore is adaptable to changed environments, has lost his finicky food habits, and doesn't need a hot water bottle at his feet and an ice pack on his head when sleeping.

From a character standpoint the forester is a fine risk in war time activities. He customarily expects his work to testify, today, in a decade, in a century, or forever, that the work was honestly, sincerely, promptly and effectively done. It would be a sad day, indeed, for American forestry to learn that American foresters took advantage of the chaotic and slip-shod administrative checks inherent in war time procedures, to aggrandize their personal fortunes. We might smile at reports of such activity in the Japanese army, we might even shrug our shoulders if some Americans took advantage of a war situation, but professional standards of decency could never condone sharp practices on the part of foresters. To the forester, the requirements of the job must come before personal considerations. Success in war demands the same attitude.

Although the physical and character qualifications of a forester indicate that he will fit into any of the wartime activities, it must be remembered that his educational background and his work skills limit materially his most effective fields of service. War activities furnish a place for all types of workers. In the complex and integrated war efforts are found all manner of jobs ranging from unskilled laborers to skilled artisans, and from strawbosses who merely perceive the "how" of the present job to administrators capable of conceiving new and better procedures.

A forester is not a common laborer, neither is he a skilled artisan. He must, it is true, work his way up from the bottom. His first tasks may be essentially those of common labor. He may become proficient in a skill or so. Some individuals may never rise above the field of perceptual leadership. However, the true forester must gradually become the creative type of administrator if he is to advance in his profession and if the profession of forestry is to perform its function of service to the nation. The history of forestry in the United States gives ample proof that the forester is a creative type of individual. Four decades ago the forester was trained in European forestry. His activities were defined as "growing crops of trees." Today the forester is considered as a manager of land. His professional discussions have to do with better ways and means of practicing American forestry in American forests. At one time forestry work was essentially that of building trails and telephone lines and fighting fire when a "four foot trench down to mineral soil around the fire" was all that man could do. Today the building of telephone lines and trails has been reduced to a skilled job and the art of forest fire fighting has grown into a complex undertaking requiring a high type of creative judgment. Forestry is undoubtedly a true profession when judged by the type of work done by foresters or by the educational standards followed by forest schools.

While it is easy, on paper, to separate the foresters from their co-workers, the division is not so clear cut in any actual field organization. It so happens that the field organizations are pyramidal in form with all types of workers involved. Trained foresters may be found working below the professional level due to lack of ability, experience, or job opportunity. Then,

too, the work of each field organization is often so complex that no clear cut line of demarcation can be drawn between those engaged in forestry work and other types of workers. Finally, the forestry leaders are called upon to integrate the forestry program into the various industrial orders involved and into the general pattern of the economic and social life of America. For this reason, it becomes necessary to discuss the present defense program in relation to forestry personnel in general terms without drawing sharp lines between foresters and non-foresters.

The defense program has already made itself noticeably felt. The recruitment of Air Corps officers has taken over 25% of our last year's junior class group in Forestry at Oregon State College. No doubt, other schools can testify to a similar record. We expect that other branches of the defense forces will bring the total absorption of this particular class of students to over 30%. Of last year's graduating class 8.9% are already actively on defense duty. Added to this number of young officers are the reserve officers who either have been, or shortly will be, called from their forestry jobs. This drain on the ranks of the foresters most certainly eases the pressures caused by the current large graduating classes. Should the enlarged defense program become permanent, a large number of these men will be permanently absorbed into the defense program.

An increased demand for young foresters has also developed in the lumber industry due to the "baby war boom" caused by the defense program. The barriers against young college men entering the industry due to the union situation are easier and the interest in such men on the part of the employers greater than has been the case for a number of years.

In consequence, the defense program must be given a good deal of credit for making placement opportunities equal to or superior to the average placement opportunities for all types of training available at the college level. It should be remembered in this regard that present graduating classes are three to four times as large as pre-depression levels and that governmental agencies are in the midst of the recession following the boom days of the early New Deal.

The effect of the selective service law in taking from the labor market a number of young men will become more apparent shortly. There is already some evidence that employers are hoping to replace these men with individuals not subject to the draft. It is to be hoped that this tendency does not become widespread. There are already too many barriers between the young man reaching maturity and his toehold job. It would be far better to flex civil service regulations and social security requirements than to have a situation develop wherein a large group of young men could not find adequate job opportunities until after they have served a year in the defense program—a year, incidentally, the timing of which is largely outside their control.

The service of forestry personnel to the defense program other than that which has been proposed must be in the field of speculation. The following items are therefore suggested as being among the possible desirable developments.

1. The more extensive use of forestry personnel in the procurement division of the defense program. The large sums being spent for lands and for supplies made of wood can be most effectively spent only by men who know many of the technical points involved. Foresters are perhaps as well fitted as any group to carry on this activity.

2. The development of an adequate plan to supply the wood requirements of war time. This would contemplate

the location and designation of the necessary raw resources and the development of a plan of utilization so that the armed forces would get the materials needed promptly and properly. This would likely require the development of small flexible units with the pre-training of a small corps of men in order that a second "twentieth engineers" could be quickly placed in efficient service.

3. The development of an adequate forest fire fighting unit. Forests are used extensively in war time for the protection of troops and for the furnishing of essential war supplies. Their protection from marauding enemy bombers would be most difficult. Incendiary bombs dropped during bad fire weather could cause considerable damage to troops harbored in forest areas or to lumbering operations. It would seem desirable therefore to develop a defensive corps of forest fire fighters for the protection of strategic forest areas.

4. There should be an extensive program designed to substitute wood for metal products. Modern warfare makes an enormous toll on the metal resources of the nation. If wood could be substituted for metal more metal would be available for combat purposes. It might be possible, for instance, to develop a plane made of plywood or moulded material with glued joints giving the flexibility of the wooden plane, the strength of the metal ship and having the advantage of being made more quickly and of having a smooth surface thereby allowing greater speeds to be attained than is now the case with the riveted metal plane.

Such a program must be based upon focusing some of the research and engineering skill on the problems inherent on a better use of wood.

5. The development of reasonable controls of the exploitive industries. The stabilization of prices to prevent war profits, the regulation of war orders so that the defense program will not be hindered, the disruption of peace-time supplies minimized and the control of the labor situation in order that production will not be interrupted with strikes or other hindrances are complex problems demanding the cooperative efforts of all qualified experts for their best solutions. Foresters should be prepared to contribute their share.

6. A full consideration of the adjustments necessary when the nation returns to a peace-time basis. War programs have a way of stopping as quickly as they start. The induction of the war time labor into peace-time activities brings with it an enormous change in the way of life. It is quite likely that a pre-planned program would enable foresters to ameliorate some of the disruptive effects involved. Thus it might be possible to bring about progress toward a type of city made up essentially of a group of individual community centers. This would allow more individuals to live in single houses thereby making it more difficult for enemy bombers to damage the civilian population than would be the case in a city with people densely housed in apartment buildings. Such a city would allow more individuals to take an active part in their community affairs thereby developing a larger citizenry with a "stake" in their home town—a type of citizenry which is the backbone of a democratic society. Incidentally, such an arrangement would increase the demand for housing and the type of recreation in which foresters are interested.

An attempt should also be made to increase the amount of effort placed in conservation enterprises. The supplying of sustaining goods, i. e., those for current consumption, tends to be in the nature of a cycle. The unfortunate effects of the business cycle can be ameliorated to a considerable degree by

developing properly the amount of effort placed in developing enduring goods. Foresters should therefore plan for and prepare the public for an enlarged conservation program to be placed in effect when the defense activity wanes. America is rich enough to afford such expenditures, the nature of the adjustments which must be made at the end of the enlargement of defense activities are such that we can ill afford not to develop our conservation activities.

Any resume of the prospective role of foresters in a defense program must be indicative rather than real. It is obvious that some foresters must take part in defense activities. Others will choose to contribute their efforts. Some will find work closely allied to their professional work, others may drift far afield due to the fact that the rapid changes brought about create work for which no one is adequately trained. Foresters may well be attracted to such work. It will be interesting to note the range of activities of foresters when the defense program is completed.

Foresters in administrative positions can exert considerable influence upon the role foresters will play. Educators can make their programs rigid, advise students to minimize defense activities and endeavor to have concessions made so that forestry students will not be called on defense activities. An opposite policy of liberality and encouragement may be followed. In a like manner, employers can discourage employees from being tempted by the opportunities made available by the unfolding of the defense program or they might choose to disrupt their own organizations in the interests of a broader field of service on the part of their men. Similarly, the forestry leadership, in general, can be conservative with the main effort being to maintain the status quo or it might be directed toward giving every effort toward dovetailing the defense and forestry activities in such a manner that the defense objectives will be effectively and efficiently reached. It is for history to record and for each man to choose as to the path to follow. For my own part, I feel that foresters should carry their full load of defense work. The men involved should be truthfully informed and those who choose to contribute their bit should find official cooperation and encouragement. Given this plus aggressive leadership and intelligent counsel, foresters will be prepared and will have earned the right to have an enlarged program and field of service in the America that is to follow the completion of the enlargement of the defense program.

The Milk Sanitation Program in National Defense

ROY M. WILEY
Milk Specialist
Washington State Department of Health

The dairy industry is one of the leading agricultural pursuits in the State of Washington and probably employs more men than any one other type of work in all industry. This makes the problem of control difficult in that there is no concentration as one would find in other industries and requires so much individual work.

It is estimated that there are more than sixty-thousand dairies in this state, including all types from the small sour cream producer to the best pasteurizing plants. In counting all milk sanitarians in the state, there are only twenty-seven which would leave well over two-thousand dairies per man. It is fairly well established through ex-

perience that one man should have no more than three-hundred and fifty dairies to inspect, provided they are well concentrated. In some parts of the state one cannot inspect more than five or six dairies a day. In many of the towns and cities the local ordinances are antiquated and need a thorough remodeling, as this fast moving industry is far ahead of them. It has only been in the past few years that emphasis has been placed on qualified men over the political appointee in some places; however, the conditions we have today are much improved over that of a few years back.

During the latter part of 1934 it was deemed advisable by the Director of Health that a survey of the milk sanitation facilities in this state be made. As a result a Milk Specialist from the United States Public Health Service was asked to come out and do this work. From his reports it was decided to have a man appointed as milk specialist in the state to assist local health departments with their milk programs and to carry educational programs to the public, as well as to assist the dairy industry wherever possible. This work was started in February, 1935 and was carried on with the assistance of the United States Public Health Service Milk Specialist until July, 1935.

It was decided through office conferences that we would carry out educational programs, such as lectures and demonstrations, attend meetings and get our program before the public without too much force until we were better established and had gained the confidence of the public. We also did rating surveys of milk sheds, and as an assistance in educational work, conducted tours of dairymen and consumers from one milk shed to another. This has proven to be very effective and we have gained exceptional results from it.

As county health depar'ments were established, there was a demand for milk sanitarians and assistance was given those departments in carefully selecting men that had the ability to assist in a constructive program and through their efforts the milk sanitation program is gaining in popularity. There are now eight men employed through the county or city health departments, covering nine counties and one city that has accepted the program and is working very effectively with it.

It was also necessary at the beginning of the program to decide on some type of ordinance to recommend to cities and counties. After stpdying many city ordinances and state laws, it was decided to use the United States Public Health Service Milk Ordinance and Code as it afforded more advantages than any other. Cognizant of the fact that there was opposition to it by the industry, due to mishandling in the past, we decided to use it carefully and not try to be aggressive but to have it adopted wherever possible and let it speak for itself. Some of the reasons for selecting this code were: It is the standard for judging milk for interstate shipment; it is standard all over the United States; and is the basis for inspections by the Army, Navy and C. C. C. Camps. Through its grading and degrading features, it affords the best type of ordinance for educational work. This is the only ordinance obtainable that has an interpretative code that can be used in the administration of it and that has untold value in the practical field.

This paper so far has dealt only with the problems confronting the industry and inspection force, but this was necessary as a foundation to explain the work necessary in the preparedness program.

Through the Surgeon Generals of the United States Public Health Service and the Army, it was decided to ask each State Department of Health in the maneuver areas to cooperate in con-

trolling the public health conditions. This in most part involved the venereal disease and sanitation problems. We were anxious to assist as it not only gave us an opportunity for good training but was a problem of exceptional value. A full report of the activities is being prepared and will be published in the near future.

An office was set up in Olympia and several members of the state office moved down temporarily. Several milk and general sanitarians from the counties, who had shown by past work that they were well qualified, were brought in and some new men were hired.

The engineers checked the water supplies and sewage disposal systems in localities where troops were concentrated and the sanitarians inspected all eating establishments, tourist camps, etc. It was a rather easy job in these departments as the sanitarian was in a posi'ion to recommend reasonable changes, such as screening, sterilization, proper cleaning, etc., and in the event the establishment failed to meet the requirements, the Army declared them "out of bounds" and refused to let the troops patronize the place. A great deal was accomplished in a very short time and was well accepted by the industry as they were aware that the things required were nothing more than reasonable. Many places asked to have it continued, but due to lack of finances, it was dropped after the National Guards were sent home.

The milk sanitation program was an entirely different problem. The Army regulations require a Grade A pasteurized milk, according to the United States Public Health Service standards if it is possible to obtain, and in the event it cannot, the highest grade milk obtainable which has been pasteurized, and as a third choice, canned milk.

The Army officers had built up a few dairies in the past to supply the normal complement of troops, but with the mobilization of the National Guard it was necessary to have about a thousand to fifteen hundred gallons of milk a day in addition to the regular supply. The officers had had a great deal of difficulty in that if their requirements became too rigid the dairymen would quit. They surveyed all the surrounding country and could find none that would pass the requirements or any that would try to meet the requirements. They were therefore at a loss. In conference with our Department, they gave us their regulations and asked us to get the milk for them. We conferred with members of the industry for some time with little success. We then got in touch with the Portland Cooperative Association and made arrangements with them to send their Grade A milk, which was produced in the Woodland, Washington section, to the Fort Lewis Dairy which meets Public Health Service requirements. The manager of the Fort Lewis Dairy and the manager of the Portland Cooperative Association conferred and reached a price agreement and the Army officers made an inspection and approved the milk supply. There were from a thousand to twelve-hundred gallons of milk a day delivered during the maneuvers and since the mobilization of troops it has gone as high as eighteen-hundred gallons a day and will be increased from the Portland milk shed unless some local dairies meet the army requirements in the very near future. However, the price paid at the Fort is high enough that a number of associations are becoming interested. The Army has turned the responsibility of the milk supply over to this department and it is creating a large volume of work. It is planned that there will be about fifty-thousand men in Fort Lewis and McChord Field by March and that will require better than five-thousand gallons of milk a day. There

is also a good possibility of around a hundred-thousand men for maneuvers this summer. Partly due to price and partly to pride the industry is demanding assistance in getting ready for this business and fortunately it is possible to work the program in such a way so that the local communities will also benefit by receiving a higher grade product. With the Army standing firm on its requirements, it also gives our Department an advantage in explaining our program and making contacts that were closed to us before. When anyone asks the Army officers for an inspection, they refer them to the State Department of Health. It seems highly possible that not only will shippers meet these requirements but also many pasteurizing plants will get ready, as some have already.

There is one other phase of the program that is lagging behind at the present time and that is controlling the consumer's indifference. The average consumer is prone to accept a bottle of milk without question so long as it has a good cream line. We hope that the consumers will soon recognize the fact that if the milk is not satisfactory for the Army, it is not satisfactory for them and in turn, with their support, we will be able to use the Army to increase the quality of milk for the civilian population, which is just as important.

Abstract

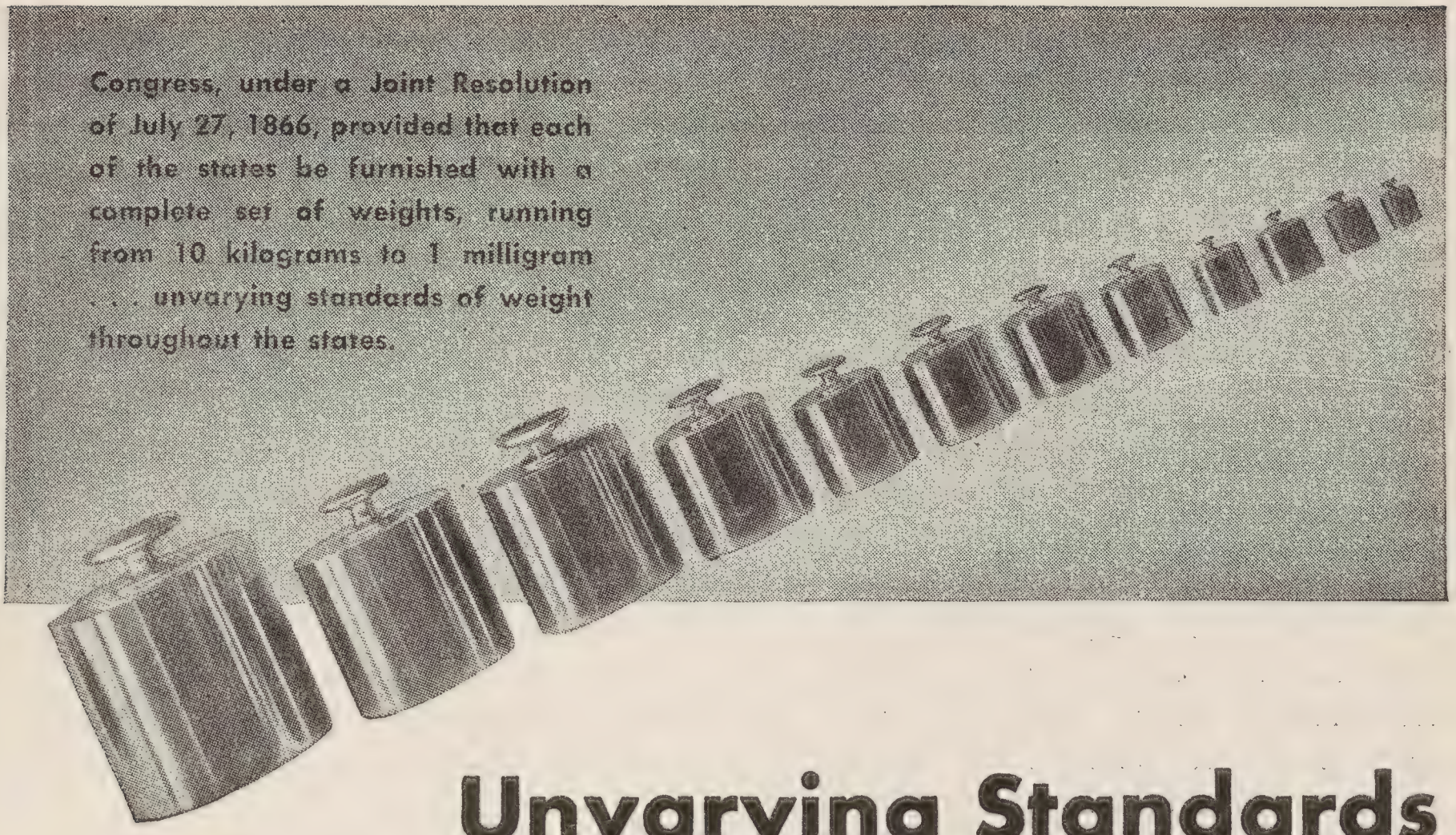
The Defense Program of the Departments of Geography and Geology at University of Oregon

WARREN D. SMITH
University of Oregon

At the present time the major department at the University of Oregon in this field is geography, while geology is a minor department only. This is due to the particular institutional set-up in the System of Higher Education in the State of Oregon. We shall first give the work most nearly related to geography. Mr. James C. Stovall, instructor in geography, who has had experience with aviation problems, has been selected as the campus director of the University pilot training work. In addition, he is giving courses in navigation for aviators, and with the cooperation of other members of the staff, has been conducting courses in map making and map reading. Though the ground work in meteorology is given in the department of physics, many of the prospective flyers also take the course in climatology given in the department of geography.

This department has constructed, with the help of both students and WPA workers, several relief maps: a new one of the state of Oregon, based upon the latest topographical information; a new map of France for the French department; and a new map of the Pacific Northwest, which takes in a portion of Alaska and runs southward into California. Other maps of the Pacific Northwest have unfortunately stopped either with the Canadian boundary or just a little north of it. Of course the Pacific Northwest as a geographical region is much larger than this.

It has seemed to members of our department that America's chief concern in the future, in the matter of defense, might well be not so much in active military operations, but in providing an adequate economic defense. It seems very likely that we shall be faced with an economic "blitzkrieg" centering upon South America in the near future, cer-



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tainly if Germany should win the war with Great Britain. To this end we have emphasized courses in South America. Courses dealing with Europe and the Pacific, stressing, for the time being, economic geography, are beiing given. We have also given this year, for the first time, a course in economic geography of the Northwest. Certainly a better understanding of the resources of these various regions is of paramount importance in national defense.

Members of our staff are also on two committees of the Eugene Chamber of Commerce, one dealing with the Willamette Valley Flood Project, and the other with forest and land conservation. One member of the staff is a member of the University committee on National Defense.

The geology department has worked into the defense picture in three different ways. Many prospectors and others continue to bring in samples of minerals and rocks for determination, and seek general advice on economic geology. As much of this work as possible is referred to the State Department of Geology and Mineral Industries, but much of it can be and is handled at the University. This is principally due to the fact that the University department has been actively in the field of geological work for many years.

The members of the staff are being asked on numerous occasions to address service clubs, granges, church forums, and schools on the subject of minerals and war. We have found a great interest on the part of the public in these matters, and also a great deal of ignorance on the subject. Therefore, this type of education seems to be of very great importance at the present time in shaping public opinion.

The third activity of the geology department is shown in the collaboration with the State Department of Geology and Mineral Industries in numerous ways. At the present time we have in preparation a bulletin on the geology of the northern part of the Wallowa Mountain Range and other material for future publications. Still another phase of the work might be referred to such as the writing of articles for newspapers and scientific journals, dealing with various aspects of the world situation, but particularly with reference to the Far East, where one member of the staff was located in economic work for some twelve years previous to coming to the University.

In conclusion, it is believed that one of the most effective things any department in a college or university can do at the present time is to give its students as thorough general training as possible, whether this training will be immediately applicable to war conditions or not. The period of reconstruction following the war will call for trained men in many fields other than the ones under immediate consideration.

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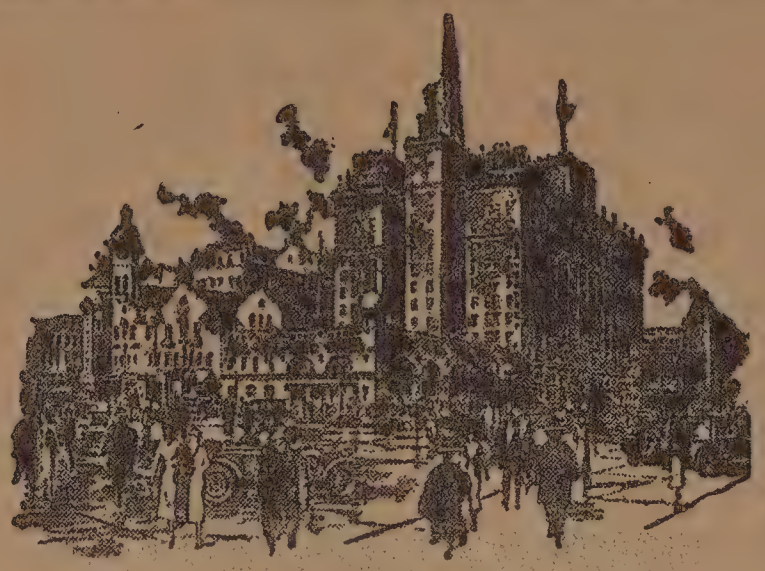

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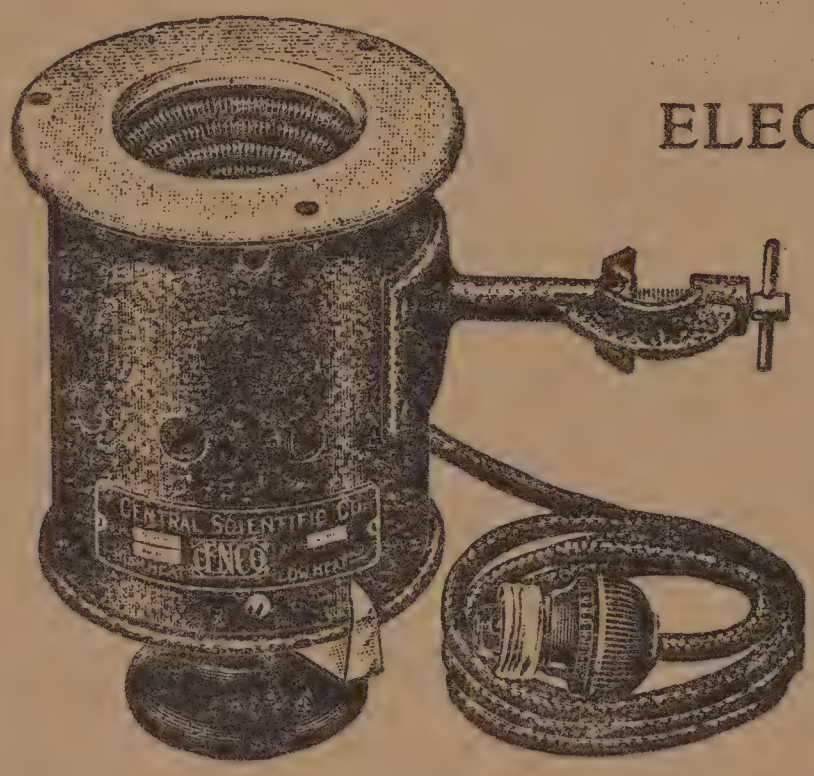

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Dr. Cox Honored by Award at Chicago Meeting of the A. A. A. S.

Dr. Herald R. Cox of the Rocky Mountain Laboratory, United States Public Health Service and a member of the Northwest Scientific Association, was the recipient of the Theobald Smith award in the Medical Sciences of the A. A. A. S. at the special "Fiftieth Anniversary Symposium" held at the University of Chicago September 22-27, 1941. The award consisted of $1000 and a bronze medal furnished by Eli Lilly and Company. Dr. Cox delivered an address on "Cultivation of Rickettsiae of the Rocky Mountain Spotted Fever, Typhus and Q Fever Groups in the Embryonic Tissues of Developing Chicks." In this address Dr. Cox explained the method he developed for producing vaccines for a group of very serious diseases by inoculating hens' eggs with their causative viruses. The new method is relatively simple, inexpensive and adaptable to quantity production. Dr. Cox has appeared twice on the programs of the Northwest Scientific Association and expects to appear on the program for this coming meeting December 29th and 30th when he will lecture on his work on "Horse Encephalitis."

Dr. Cox was born at Rosedale, Ind., and after receiving his Doctor of Science degree, helped develop a vaccine against Rocky Mountain Spotted Fever. Dr. Cox like many of his colleagues literally took his life in his hands while working with the highly virulent germs of spotted fever, typhus and other tick-borne diseases. He has cultivated and studied strains of spotted fever obtained from South America, Africa and Australia.

The particular work for which Dr. Cox received the A. A. A. S. award at Chicago consists in injecting with a hypodermic needle the germs obtained from ticks into the yolk sac of developing chick embryos. The injections killed the eggs after three or four days, but the germs, still alive, could be passed on through successive eggs. Through some process not yet understood the fluid of the yolk sac, after serving as the food for the germs, is converted into vaccines which can be used in the prevention of disease. After the germs have been passed through the yolk sacs of the eggs from five to ten times and then inoculated into guinea pigs "the course of infection is noticeably lessened" and the animals often have only "immunizing infections" similar to the protective effects of cowpox infection which prevents smallpox.

Dr. Cox states: "The features that make the yolk sac technique of particular value" in preparing vaccines "are its extreme simplicity and the ease with which cultures of germs can be maintained for carrying on mass production of protective substances."

Dr. Cox's paper, "Cultivation of Rickettsiae of the Rocky Mountain Spotted Fever, Typhus and Q Fever Groups in the Embryonic Tissues of Developing Chicks," presented at Chicago, was published in Science, October 31, 1931, vol. 94, pp. 399-403.

A popular description of the work of the Rocky Mountain Laboratory at Hamilton appeared in the Saturday Evening Post for Nov. 15, 1941.

☆

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Association Meeting, December 29-30, Davenport Hotel, Spokane, Washington

At the time of going to press, plans for the meeting of the Northwest Scientific Association, December 29 and 30, at the Davenport Hotel, Spokane, Washington, are not complete, but it is certain that a very interesting program is being arranged and meetings should be very successful. Mr. George Yantis of the Natural Resources Planning Board will be one of the principal speakers at the general meetings. Complete programs will be presented by the following sections: Botany-Zoology, Chemistry-Physics-Mathematics, Bacteriology-Public Health, Engineering, Forestry, Soil Conservation, Geology-Geography, and Social Science. It is also possible that a new section on range and wildlife management will be organized with a special program. The theme for the forestry section will be "Recent Developments in Forestry" and already ten men have agreed to appear on the program.

In Memoriam

The Northwest Scientific Association, the State College of Washington, and people of the Northwest in general have suffered a serious loss in the deaths of Enoch A. Bryan, President Emeritus, and Dr. Hubert V. Carpenter, Dean of the College of Mechanical Arts and Engineering. Both men had been active in the affairs of the Northwest Scientific Association and will be remembered for the comprehensive papers presented at the general meetings. Obituaries of both men will appear in the February issue.

Abstract
MOUNDED FANS IN THE COLUMBIA PLATEAU AREA, WASHINGTON

J. H. MACKIN
University of Washington

Alluvial fans along the sides of coulees in the Columbia Plateau exhibit two types of surface form, one type being the smooth radial slopes of the conventional fan, and the other being characterized by small hillocks or mounds on the fan surface. In general, large low-gradient fans tend to be smooth surfaced, and small high-gradient fans tend to be mounded, but there are intergradations, and both types of surface form may occur on different radial segments of the same fan. The mounds may attain a height of six feet, are generally elongate with the steeper end down the slope, and are made up largely of angular blocks of basalt.

The following hypothesis for the origin of the mounds is offered: Small channels in the uplands become partly filled by slope wash and by mass movements of loessic upland soils during the long intervals between times when they carry running water. When runoff occurs, especialy when thawing surface soils rest on frozen sub-soil, mud flows may originate both in the stream channels and on soil mantled slopes. The pasty mass, carrying with it angular blocks of basalt, moves out onto the fan and terminates as a steep-ended tongue of mud on the fan surface. The mud flow phase may or may not be followed by a phase of running water. Rain falling directly on the fan subsequently washes away the fine mud, leaving a mound of angular basalt blocks.

Such mud flows, terminating on fans, are of very infrequent occurrence, but the mounds of basalt, once formed, are long lived. They may be destroyed only by burial or by the active cutting of a relatively large stream of water. For this reason they are common only on small fans which apex in valleys with restricted drainage area, and are rarely seen on the fans of larger upland streams.

Abstract
THE LIFE HISTORY OF LACHNOBOLUS CONGESTUS LISTER

ROBERT C. HARE
State College of Washington

The life history of **Lachnobolus congestus** (Somm.) Lister has been described for the first time, and its successful culture carried out on artificial media. The plasmodium of this myxomycete is a ramifying network of white filaments, apparently living as a saprophyte on decaying wood and bark. Its fruiting body consists of a cluster of sporangia which are at first white but later turn brown. The sporangia are filled with small round spores and a scanty capillitium. Under moist conditions the spores germinate to form, at first, motile myxamoebae, which soon develop single flagella, and later elongate and become fixed in shape. Sexual fusion follows, forming biflagellate zygotes. Attempts at inducing plasmodium formation from the swarm spores, either on artificial or natural media, were unsuccessful. An agar medium made up with a bark decoction was found to be relatively free from extensive mold growths, and proved most satisfactory in supporting the growth of the plasmodium.

A BLOTCH AND CHAR-SPOT OF WESTERN GRASSES[1]

RODERICK SPRAGUE[2]

Septogloeum oxysporum Sacc. Bomm. et Rouss., although typically recognized as a blotch-causing parasite on certain European grasses, occurs widely in western North America not only as a blotch disease in its early stages but also as a charcoal-like, leaf streak on a number of grass hosts in the area. A list of the hosts and collections studied in connection with this note is given in table 1.

Symptoms.

The leaves are first spotted with tawny, yellow margined, circular but soon elliptical to elongate lesions. The fungus on *Arrhenatherum elatius* rarely forms black stromata, but on other hosts the lesions become covered with dull-black, charcoal-like streaks, 2-5 mm. wide and often several times as long. While the charcoal spots range from nearly circular to elongate, they are typically elongate, tapering to a point at each end. The center of the lesion is often paler than the periphery, being pale gray or isabelline from accumulation of conidia in some instances. Sometimes pycnidia occur as small black dots at the margin of the lesion but more often, if they are present, they are obscured by the charcoal-like stroma and are not visible to the naked eye.

Pure Culture Studies.

Isolations were readily obtained from *Arrhenatherum elatius* at Corvallis, Oreg., on potato-dextrose agar and were maintained for about two years at 40° F. before staling took place. The growth was moderately slow, pale buff with tawny shades. Conidia were produced in great numbers for a considerable period after which the cultures staled to a flat tawny-colored, sterile growth.

Morphology.

The spores are borne on stromatic tissue, in obscure acervuli or in pycnidia, usually in the center of the lesion or about its periphery. The spores arise from hyaline, globular or sub-cuspidate conidiophores (Fig. 1, A) and are usually produced in such large numbers that they sometimes appear as grayish masses in the center of the lesions.

The conidia are yellow to sub-hyaline, fusoid, often flattened slightly on one side, sub-truncate at the base tapering to an obtusely pointed apex. The conidia are 0- to 3-septate but in most collections they are uniformly 2-septate. However, in some collections on *Arrhenatherum elatius* and in the collection on *Distichlis stricta* from Mandan, N. Dak., there are many spores with three septa (Fig. 1,B,F). Usually the 3-septate spores are larger than the ones with fewer septa. Spore dimensions for the various collections are listed in table 1. The spores have very similar size ranges in the collections on the same host. Those on *Agrostis hallii* and *Calamagrostis inexpansa* average slightly smaller (Fig. 1, A) than those on *Arrhenatherum elatuis* (Fig. 1,B), while those on *Elymus* spp. are more erratic with large aberrant forms occurring (Fig. 1,C,D). The spores from *Distichlis stricta* (Fig. 1,F) were relatively short and thick, and ranged from fusoid to nearly cylindrical.

Char spot material showing pycnidia was found at Mt. Wagoner, Wyo., Logan, Utah, Bozeman, Mont., Berkeley and Weed, Calif. The pycnidia are subglobose, brown, more or less imbedded in the creosote brown stromatic tissue, or separate at the margin of the lesions. The pycnidia are 80-160 μ in diameter with ostioles variable, but up to as large as 60 μ in diameter. Pycnospores do not differ from conidia borne on stromatic tissue except that they are hyaline or

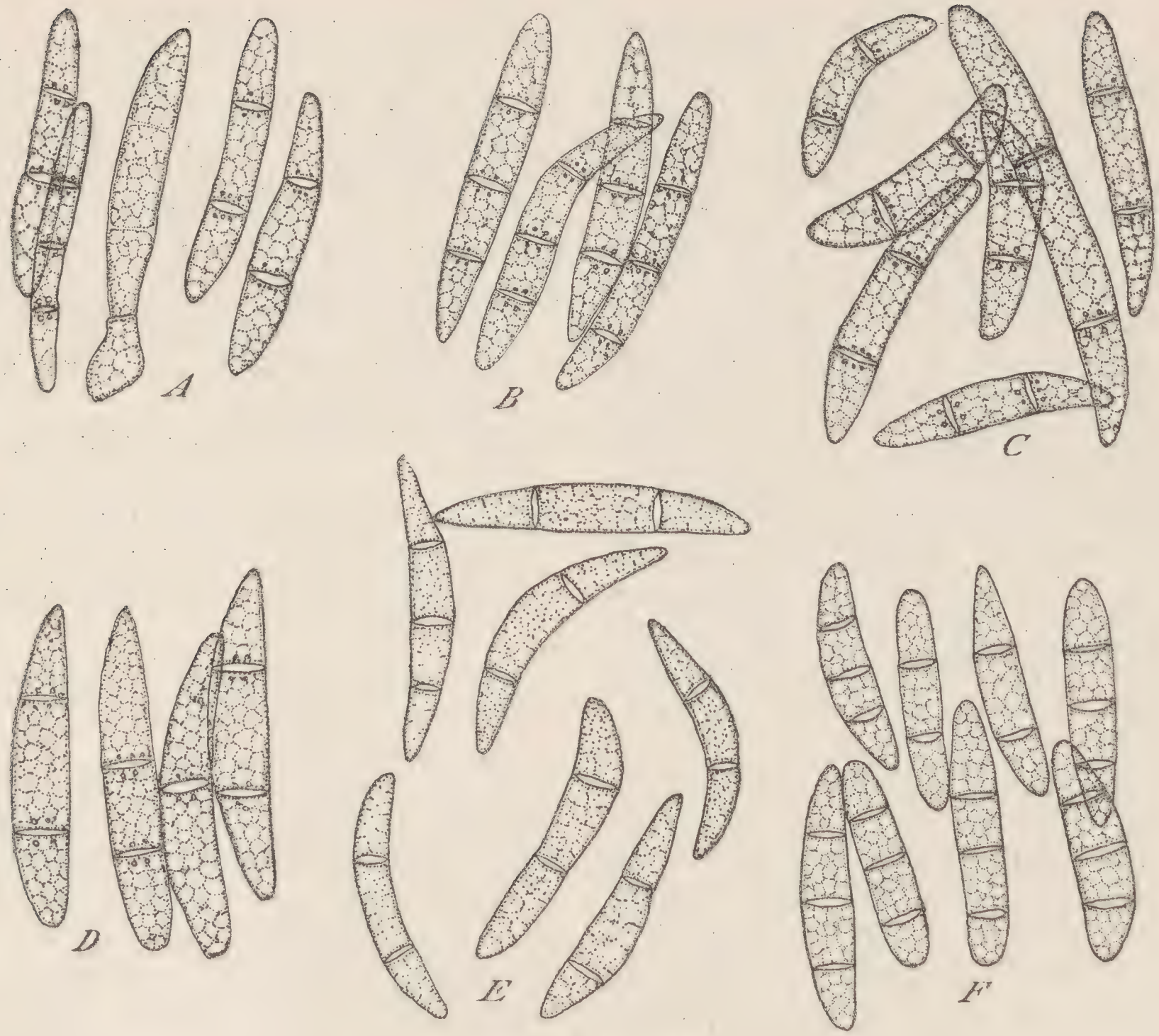
[1]Cooperative investigations between the Divisions of Cereal Crops and Diseases, and Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon and North Dakota Agricultural Experiment Stations. Published with the approval of the Director of the Oregon Agricultural Experiment Station as Tech. Paper 379. Contribution from the Department of Botany of the Oregon State College.

[2]Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture. The author is indebted to Dr. A. G. Johnson for his thorough checking of the literature.

TABLE 1.—Spore dimensions of different collections of *Septogloeum oxysporum* Sacc. Bomm. et Rouss. made in the western United States.

Accession number	Host	Place	Date	Collector	Spore Size
					μ
Wyo. 82,498[a]	*Agropyron spicatum*	Mt. Wagoner, Wyo.	Aug. 5, 1923	Payson and Armstrong	20-38 x 2.5-5.0
OSC 24[b]	*Agrostis hallii*	Near Corvallis, Oreg.	Dec. 15, 1937	W. B. Cooke	21-29 x 3.3-4.1
OSC 66	*Agrostis hallii*	Corvallis, Oreg.	Feb. 8, 1938	R. Sprague	22-29 x 3.4-4.0
OSC 188;216	*Agrostis hallii*	Alpine, Oreg. and area	Apr. 14, 1938	R. Sprague	24-31 x 3.9-4.4
OSC 8278	*Agrostis hallii*	10 mi. so. of Corvallis	May 15, 1937	R. Sprague	22-27 x 3.2-4.0
OSC 8304	*Agrostis hallii*	Corvallis, Oreg.	Sept. 4, 1914	H. S. Jackson	———
OSC 10,236	*Agrostis hallii*	Willamette Grange, Oreg.	May 10, 1935	R. Sprague	26-29 x 3.8-4.0
OSC 10,813	*Agrostis hallii*	8 mi. so. of Corvallis	Nov. 18, 1934	R. Sprague	25-28 x 3.5-4.0
OSC 23	*Arrhenatherum elatius*	Corvallis, Oreg.	Dec. 15, 1937	W. B. Cooke	26-31 x 4.4-4.7
OSC 57;57;63	*Arrhenatherum elatius*	Corvallis, Oreg. and area	Feb. 8, 1938	R. Sprague	29-33 x 4.4-4.7
OSC 713	*Arrhenatherum elatius*	Astoria, Oreg.	Aug. 31, 1939	R. Sprague	24-30 x 3.8-4.3
OSC 794	*Arrhenatherum elatius*	Corvallis, Oreg.	Mar. 6, 1940	R. Sprague	26-29 x 4.1-4.6
OSC 10,136	*Arrhenatherum elatius*	Corvallis, Oreg.	Jan. 1, 1934	R. Sprague	24-30 x 3.8-4.3
OSC 10,866	*Arrhenatherum elatius*	Corvallis, Oreg.	Jan. 2, 1935	R. Sprague	———
B.P.I. 80,008[c]	*Calamagrostis inexpansa*	Near Lisbon, N. Dak.	July 15, 1940	R. Sprague	22-27 x 3.5-4.0
———	*Bromus ciliatus*	Ouray, Colorado	Aug. 5, 1919	E. Bethel	21-31 x 3.3-4.8
B.P.I. 80,061	*Distichlis stricta*	Mandan, N. Dak.	Aug. 4, 1915	J. T. Sarvis	20-25 x 4.3-5.0
———	(?) *Elymus* sp.	Berkeley, Calif.	May 2, 1918	E. Bethel	17-23 x 2.7-3.9
———	*Elymus condensatus*	Yellowstone Park, Wyo.	June 27, 1925	P. A. Young	22-26 x 3.8-4.4
———	*Elymus condensatus*	Near Weed, Calif.	May 21, 1939	R. Sprague	23-27 x 4.0-4.6
OSC 8294	*Elymus condensatus*	Washtucna, Wash.	May 21, 1937	Geo. W. Fischer	24-29 x 3.8-4.7
B.P.I. 80,004	*Elymus condensatus*	Hooper, Wash.	May 8, 1940	Geo. W. Fischer	25-33 x 4.1-6.0
B.P.I. 80,047	*Elymus condensatus*	Logan, Utah	Sept. 1940	Wm. Rader	———
———	*Elymus condensatus*	Bozeman, Mont.	Oct. 6, 1935	P. A. Young	———
B.P.I. 80,003	*Elymus glaucus*	Logan Canyon, Utah	July 14, 1940	Geo. W. Fischer	22-29 x 3.5-5.0 (rarely 47 μ)
B.P.I. 80,046	*Elymus glaucus*	Logan, Utah	Sept. 1940	Wm. Rader	———

(a) Rocky Mtn. Herb., Univ. of Wyoming, Laramie. A fragment sent by W. G. Solheim is filed at Oregon State College, Corvallis, Oreg. as Acc. No. 597 in the Mycological Herbarium of the Department of Botany.
(b) Accession numbers of Mycological Herbarium Department of Botany, Oregon State College, Corvallis, Oreg.
(c) Bureau of Plant Industry, Mycological Collections accession number. These collections are being filed in the collections at Washington, D. C.



TEXT OF FIGURE

Fig. 1 *Septogloeum oxysporum* Sacc. Bomm. et Rouss.

A, Conidia from *Agrostis hallii,* Corvallis, Oreg. One of the spores has a conidiophore still attached and broken away from the parent stroma; B, Conidia from *Arrhenatherum elatius,* Corvallis, Oreg., O.S.C. 23; C, Conidia and pycnospores from *Elymus glaucus,* Logan Canyon, Utah, July 14, 1940, G. W. Fischer (B.P.I. 80,003); D, Conidia from *Elymus condensatus,* Hooper(Wash., May 8, 1940, G. W. Fischer; E, Pycnospores from *Agropyron spicatum,* Mt. Wagoner, Lincoln Co., Wyo.; F, Pycnospores from *Distichlis spicata,* Mandan, N. D., Aug. 4, 1915, J. T. Sarvis.

All drawings made with the aid of the camera lucida, x 1,000.

essentially so. In the material on *Agropyron spicatum* from Mt. Wagoner, Wyo., the spores are more frequently sub-falcate than in other collections (Fig. 1,E).

Details of the developing stroma and ascigerous stage have been noted in the collections. The perithecia are globose to very strongly flattened and as much as 250 μ in diameter with the stroma composing the wall of the perithecium. Most of the perithecia are filled with hyaline prosenchyma, which contrasts sharply with the creosote-brown, compacted, polygonal cells of the stromatic wall. Nearly mature asci, which are short, fascicled and without paraphyses, were noted in material on *Elymus condensatus* collected at Logan, Utah (B. P. I. 80,047).

Taxonomy.

When the writer first collected *Septogloeum oxysporum* on *Arrhenatherum elatius* in Oregon he referred it to *Fusoma* sp.[3] on the basis of the illustration of *F. biseptatum* Sacc. in Rabenhorst (4, p. 395)[4], which is a copy of Saccardo's illustration (6, pl. 184, fig. 15). Through the courtesy of H. A. Edson and John A. Stevenson material and pure cultures were sent to H. W. Wollenweber for comparison with European material. Wollenweber replied as fol-

[3]Sprague, R. A preliminary check list of the parasitic fungi on cereals and other grasses in Oregon. U. S. Dept. Agr., Bur. Plant Indus., Plant Dis. Reptr. 19: 156-186. July 15, 1935. (Mimeographed.)

[4]The numbers in parenthesis refer to literature at the end of the text.

lows: "Der ——— Pilz ist ein *Septogloeum* und unterscheidet sich von *S. oxysporum* (Konidien in diagn. 2-3 sept. 30-33 x 4 μ) anscheinend durch etwas dickere Konidien. Sie sind in Ihrer Agarkultur 2-3-, seltener 1-septiert und messen 3-sept. etwa 30 x 5.2 (23-30-39 x 4-6 μ) und 1-sept. 26 x 4.8 (20-31 x 4.5-5 μ). Da die Sporen etwas gequellen erschienen, werden sie auf anderen Substraten veilleicht schmaler und dürften dann den Grössen für *S. oxysporum* noch besser entsprechen als in der Einzelkultur". He referred to Nos. 442-445 of his Fusaria autographie delineata (10, 11) as illustrations for this fungus, which he mentions occurs on *Agrostis vulgaris, Briza media,* and *Calamagrostis* spp. in Sweden, Russia, and Germany.

In the original description of *Septogloeum oxysporum* (1, p. 294) the name and authorities are written as follows: "*Septogloeum oxysporum* Sacc. Bomm. Rouss." However, when Saccardo (5, p. 497) included the species in his Sylloge Fungorum, he wrote the name and authorities as follows: "*Septogloeum oxysporum* Bomm. Rouss. Sacc." The order of the authorities should be that as given in the original description.

The writer is convinced that the fungus in question on western grasses listed in table 1 is *Septogloeum oxysporum* Sacc., Bomm. et Rouss. *Septogloeum oxysporum* has been known by a number of names but it is earlier than the others, having been established in 1890 (1, p. 294). In 1891, Eriksson (2, No. 394) described and distributed *Mastigosporium album* var. *athrix* Erikss. nov. var. on *Calamagrostis arundinacea* from Sweden. In 1939, Sprague (8, p. 298) mentioned that this did not belong as a variety of *M. album* and transferred it to the genus *Septogloeum* and suggested further that it probably was the same as *S. oxysporum.* It appears to be identical with *S. oxysporum* collected on *Agrostis hallii* in Oregon. The relation of *Fusoma biseptatum* Sacc. and of *F. triseptatum* to *Mastigosporum* and incidentally to *Septogloeum* has been discussed previously (8, p. 298). *F. biseptatum* is an obvious synonym of *Septogloeum oxysporum* but *F. triseptatum* is by description only. It has been confused with *F. rubricosum.* The entire synonomy is as follows:

Septogloeum oxysporum Sacc. Bomm. et Rouss. 1890 (1, p. 294) Syn.
Mastigosporium album var. *athrix* Eriks. 1891 (2, No. 394).
Fusoma biseptatum Sacc. 1891 (3, No. 683).
Fusoma triseptatum Sacc. (based on description only) 1892 (5, p. 566).
Fusarium osiliense Bres. and Vesterg. 1900 (9, p. 33).
Septogloeum athrix (Eriks.) Spr. 1939
Septogloeum athrix (Erikss.) Spr. 1939 (8, p. 298).

As mentioned previously the melanconiaceous phase of the above fungus is followed or accompanied by a sphaeropsidaceous stage and in some cases by an immature perithecial stage as well. Undetermined collections in western herbaria and in the Mycological Collections of the Bureau of Plant Industry, Washington, D. C., contain all stages of this fungus. It has been a common error, of which the writer is also guilty, to consider the fungus as an immature stage of *Phyllachora graminis* (Pers.)[5] Fckl. However, material collected recently, indicates that the ascigerous stage is not a *Phyllachora* but more likely is near Dothidella. The most nearly mature material of the group, on *Elymus condensatus* (B. P. I. 80,047), was recently sent to C. R. Orton. He very kindly replied that it was not a *Phyllachora,* that he believed it was the same fungus that is sometimes known as *Phyllachora aristidae* but which he says is more likely better placed in *Eurychora* by Thiessen and Sydow. In referring to Seymour's check list (7), we find a considerable list of synonyms for this fungus. Seymour preferred *Dothidea aristidae* (S.) Ell. but some workers, including the writer, prefer *Dothidella aristidae* (S.) Ell. and Ev. What appears to be very

[5]Loc. cit.

close to if not identical with *Dothidella aristidae,* is a very common char spot on *Distichlis stricta* in North Dakota, west to Washington and Oregon. The writer has mentioned finding the *Septogloeum* stage in North Dakota material. He has, however, examined *Distichlis* material from Oregon at various times over a period of years without finding either conidia or perithecia. He has seen *Dothidella aristidae* on *Distichlis stricta,* collected by Wm. Cusick in Oregon many years ago, but determination of the fungus was based only on the very typical char spot symptoms. Recently Fischer[6] reported *Dothidella aristidae* on *Distichlis stricta* from Washington and Oregon.

The writer is convinced that the stromatic phase, the pycnidial, and the *Dothidella*-like immature perithecial stage are all stages of the same fungus, but it is not possible at present to assign *Septogloeum oxysporum* to *Dothidella aristidae* because it has not been proved that the fungus on *Elymus,* for instance, is the same as the fungus on *Aristida.* In some miscellaneous collections sent by John A. Stevenson, a trace of a *Septogloeum*-like fungus was found, in one mount, on Aristida sp. from Mississippi, but a *Hendersonia*-like conidial or pycnidial stage was noted also.[7]

Discussion.

It is the purpose of this note to present evidence that the blotch and char spot of these several western grasses is due to a fungus having not only *Septogloeum oxysporum* as part of its life cycle but also a pycnidial and an ascigerous stage. It is expected that further study will disclose determinable material that specialists in the ascomycetes will be able to classify. In that event, the char spot and blotch fungus will be definitely assigned to the ascomycetes. For the present, the fungus must be left as *S. oxysporum.* To transfer it to its pycnidial stage would be most futile, particularly because there is much doubt as to where in the Sphaeropsidales this fungus should go. Examination of several collections shows that the pycnidia are more often than not imbedded in the thin but definite stroma. This rules it out of *Stagonospora* and suggests possibly *Stagonostroma* Diedicke; but a critical study of the description only of this genus indicates that the material under consideration does not belong to this genus. Because the path of this problem is already strewn with the wreckage of abortive attempts to classify this fungus, we prefer to outline its present status with increasing faith that its final classification is within sight.

Summary.

The tawny leaf blotch of some Pacific Coast grasses and the charcoal or char spot of some western grasses is caused by *Septogloeum oxysporum.* This fungus produces stromata in which pycnidia and perithecia occur. It is expected that the fungus will eventually be assigned to a *Dothidella*-like genus. It is related to if not identical with the fungus known sometimes as *Dothidella aristidae* (S.) Ell. and Ev.

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[7]The status of *Hendersonula aristidae* (S.) Ell. has not been studied.

EFFECTS OF CERTAIN MICRO-ECOLOGICAL FACTORS ON THE GERMINABILITY AND EARLY DEVELOPMENT OF EUROTIA LANATA

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Many of our desert ranges are rapidly being denuded of their usable forage plants. Preliminary governmental investigations have shown that precautions can be undertaken not only to conserve but to restore many of our valuable desert species. Of considerable import, from among these, is *Eurotia lanata,* a valuable forage plant, the stability of which is seriously threatened in many areas, and whose recent history has been one of continued retreat from its former distribution over the western country.

The adjustment of a plant to a new set of conditions (ecesis) involves the three essential functions of reproduction, germination and growth. Germination is the first critical process of ecesis. Upon it depends the vital problem of establishment. An understanding of this basic function is essential to the eventual restoration of *Eurotia.* The present depleted condition of our desert is evidence that such investigation is needed.

Distribution and Ecology.

Eurotia lanata extends from Saskatchewan and Manitoba to western Nebraska, Colorado, western Texas, California, and Washington. It occupies the lower foothills, plains, and valleys where relatively dry soils are impregnated with alkali or salts, and is often the dominant and conspicuous plant. *Eurotia* is remarkably resistant to drought because of its deep tap-root and numerous lateral roots as well as its morphological and perhaps physiological makeup.

Eurotia is a dicot. The seed is subtended by two closely united bracts surmounted by two short "ears". Fine, silky, white hairs one-eighth to one-quarter of an inch in length arise externally from the bracts, characteristically forming four dense, spreading tufts. A white, stellate pubescence densely covers both the inner and the outer walls of the bracts, especially near their apices. The hairy pericarp lying within the bracts and immediately enclosing the seed is elliptical in shape and surmounted by two thread-like styles which have remained intact long after the fertilization of the mature female gametophyte. The seed itself consists of a tough outer testa enclosing a membraneous endosperm or perisperm in which a horseshoe-shaped embryo is the conspicuous feature. The embryo is so curved that the tip of the radicle lies in close proximity to the apices of the two seed leaves and thus encircles the unabsorbed portion of a starchy endosperm.

Methodology in General.

In carrying to completion the ensuing series of experiments, designed primarily to investigate the germinating and early developmental habits of *Eurotia lanata,* it has been expedient to comply with methods recommended for this type of investigation.

The test of germination was designed to determine the viability of the seeds and the success of the seedlings. In order thus to secure information of value to its ultimate user, growth must first be induced in all seeds capable of growth, and secondly, data must be so interpreted that results will be of greatest possible accuracy. Variation in interpretation of a test is probably the most frequent cause of discrepancy in any seed-germinating operation. In

this instance a seed was considered to have completely germinated when it had developed into a normal seedling which might reasonably have been expected to continue its development in soil under favorable conditions.

For all experiments purporting to measure germination, tests were made in sterilized petri dishes on thin, moistened pads of absorbent cotton. The very brief germinating period of *Eurotia* lent itself well to the maintenance of definite concentrations of substances where such were needed. In all cases necessary replication and randomization were applied. Except where circumstances of the test required otherwise, seeds were collected from the same source. Tests were conducted so as to measure, in so far as possible, the ultimate effect of a single factor upon the action of the seed. A single test involved but one variable, and was otherwise maintained under uniform, but not constant, conditions.

Imbibition.

In the present test of the imbibitional powers of *Eurotia seeds,* four solutions —distilled water, 1.5%, 3.0%, and 5.0% sodium chloride—were used. Solutions were maintained at approximately 76 degrees Fahrenheit. At the end of a 2 hour interval no marked difference could be noted in the amount of water imbibed from each solution. With increase in time of soaking, however, the amount of water imbibed increased quite abruptly in pure water and less sharply up the scale of salt concentrations. At 24 hours the seeds in distilled water had nearly tripled their original weight. Seeds in the 5.0% NaCl solution showed an increase of about four-fifths of their original weight.

Effect of Storage.

Seeds of *Eurotia* collected in 1935, 1936, 1937, 1938, and 1939 were used for the present experiment, which was begun December 9, 1939.

Data taken from this experiment indicate a considerable loss of vitality by seeds of this species after the first year. Seeds from the 1939 collection gave 97 per cent germination while 83.5 per cent produced healthy seedlings. 1938 seeds germinated 87 per cent with a 72.5 per cent seedling production. Germination in the 1937 lot declined sharply to 23.5 per cent while the healthy seedlings produced therefrom amounted to only 10.5 per cent of the total. In the case of both the 1936 and 1935 lots germination was negligible, with practically no healthy shoots being produced. It is to be noted that the 1938 seeds showed fairly high seedling production. This might be attributed to the fact that the seeds were slightly more than a year old, and had not yet reached the point where the slump in vitality becomes most distinct. This was substantiated by a test of 1938 seeds from the same source two months later, which showed only a 47 per cent seedling production under quite similar conditions.

The rate of germination also declined with the increasing age of the seed. While in the 1935 lot only 20 per cent of the recorded germinations had occurred within 24 hours, it is significant that in the 1939 lot over 50 per cent of the total germinations had appeared in less than 12 hours after planting.

It becomes evident then that seeds of *Eurotia* must establish themselves during the late winter and early spring of the year following their production. Should unfavorable conditions prevail over that period, it is evident that plant production would be seriously retarded due to failure of the seeds the following year. Apparently the high imbibitional powers of the seed are offset by its failure to hold the amount of water required by the embryo to maintain the protoplasm of its cells.

Dormancy.

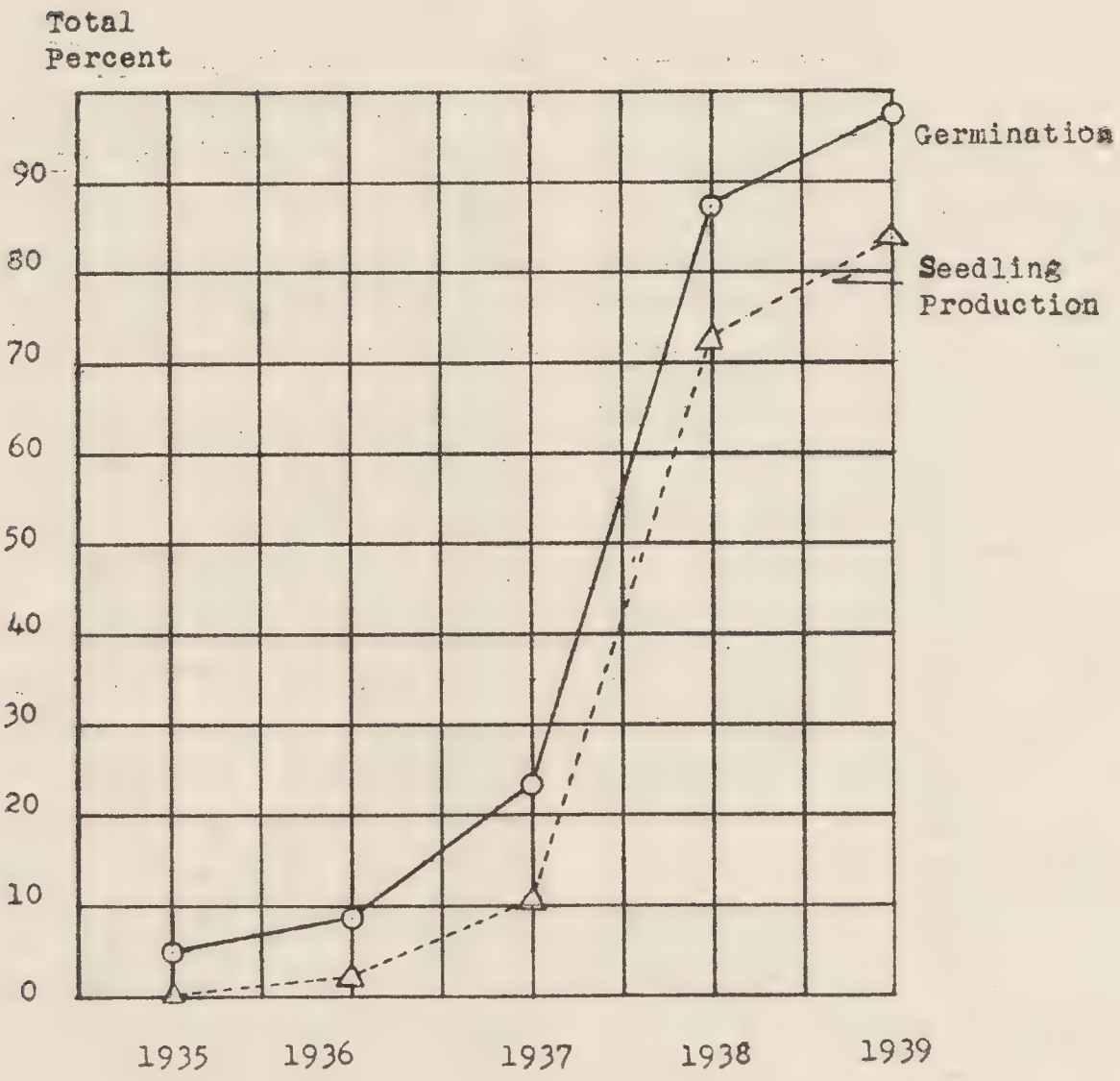
Eurotia seeds removed from the par-

Eurotia seeds removed from the parent plant on October 13, 1939, were placed in germinators nine days later. After 3 weeks 12 per cent had germinated. These same seeds, stored in air-dry

24

Graph 1

Showing viability of seeds of Eurotia lanata and loss of same with storage



conditions at greenhouse temperature showed 52.5 per cent germination after 1 month, 67 per cent in 2 months, 62 per cent in 3 months and 54 per cent in 4 months after storing. Under similar conditions, seeds removed from Eurotia plants in late November, 1939, showed a 99 per cent germination when tested in the following February. All tests were at temperatures of 65-76 deg. Fahrenheit. Seeds of the November lot attained their 99 per cent germination within 4 days after planting, while the October seeds in the same February tests required 10 days to achieve their 54 per cent total germination.

When kept at freezing temperatures, and in a moist state, seeds of the October collection germinated 90 per cent after one month. At the end of 3 months it was still germinating between 90 and 92 per cent. Seedlings produced by the October seeds, however, were usually unhealthy and deformed, while seeds from the November collection produced vigorous, highly colored seedlings. In attempting to overcome the apparent quiescence of seeds from the October lot various treatments, including exposure to -30 degree C. temperature for 24 hours, were resorted to without success.

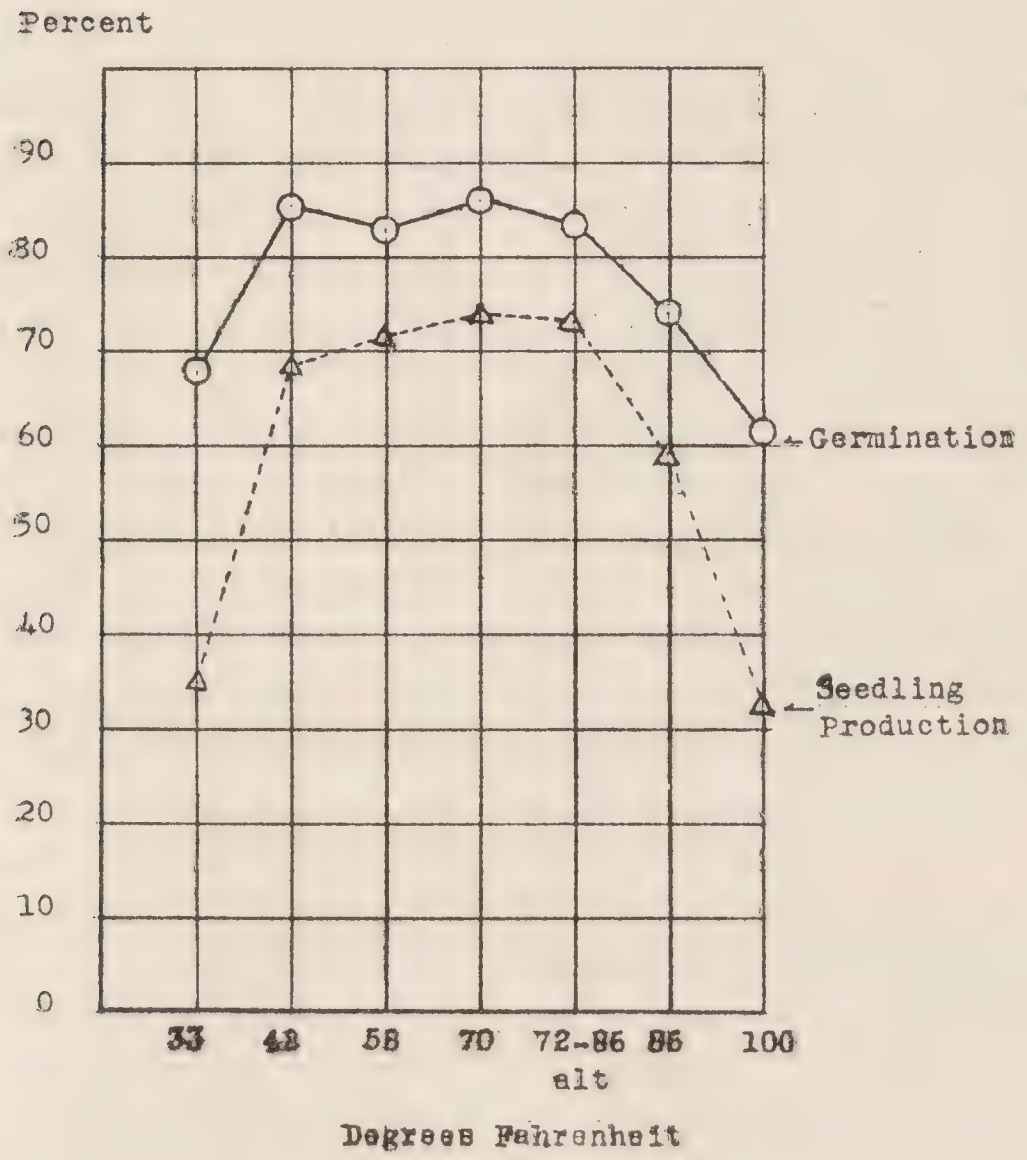
Temperature Extremes and Optimums.

Tests on 1938 seeds of **Eurotia** were carried on at temperature means of 33, 42, 58, 70, 86, and 100 degrees Fahrenheit plus an additional alternating temperature condition of 72 degrees F. for 18 hours and 86 degrees F. for 6 hours

37

Graph 2

Showing effect of temperature upon the germination and seedling production of seeds of Eurotia lanata



daily. Proceeding from the lowest to highest temperatures germinations of 68, 85.5, 83.2, 86, 74, and 61.3 per cent, and at alternating temperatures 83.4 per cent germinations were recorded. Seventy-three per cent of the seeds at alternating temperatures produced healthy seedlings. Germination was delayed considerably at the lower temperatures but the resulting seedlings were quite normal. At the higher temperatures (86 and 100 deg. F.) germination did not proceed as promptly as at the medium temperatures and seedlings soon began to wilt and soon died if not removed from these conditions.

Seeds which germinated barely above the freezing point (33 deg. F.) showed very little progress beyond the early seedling stage unless removed to higher temperatures, whereupon growth immediately was resumed and healthy plants were obtained. Certain of these seedlings were permitted to remain at freezing temperatures for over a month without notable growth and apparently without impairing their vigor for upon removal to temperatures 10 degrees higher (42 deg. F.) ordinary development recommenced.

In another instance fresh 1939 seeds of *Eurotia* were germinated at a mean minimum temperature of 25 degrees F. for 16 hours and a mean maximum of 58 deg. F. for 8 hours each day. Though frozen solid 16 hours out of 24, vigorous shoots appeared promptly, and within 7 days seedling production had reached 95 per cent.

Large soil flats were sprinkled with

fresh unsorted seeds, in their bracts, and placed outside the greenhouse on December 29, 1939. About 2 weeks later the snow-covered flats exhibited numerous germinations. By the first of February hundreds of normal, highly-colored seedlings had become established. Local weather records showed temperatures ranging as low as 11 degrees Fahrenheit. The mean minimum for the month of January was 26 degrees F., and the mean maximum 38 degrees, with a mean average temperature of 32 or barely freezing. Within 3 months from planting these plants had begun secondary growth and were on their way to becoming healthy vigorous plants. Apparently only the most severe weather conditions undermine the normal functioning of fresh *Eurotia* seeds.

In contrast to this experiment was one carried on in July and August of 1939 with temperatures approaching a mean maximum of 91.4 deg. F. and a mean average of 78.3. Three plots of seedlings were set out, one group of which was watered on alternate days, one weekly, and the third on alternate weeks. In the very early seedling stage mortality was very high regardless of watering schedule. Surviving seedlings from the alternate daily and the weekly schedule developed normally until beyond the seedling stage. Plants on bi-weekly schedule did not survive this stage. Later most plants on the weekly schedule began to assume an ashen gray color. That their vitality was still largely retained, however, was evidenced when additional water was supplied and new, green shoots began to appear. Probably *Eurotia* plants are well estalished long before the onset of summer conditions.

Salt Effects.

Salt tolerance tests were conducted in 11 lots corresponding to different sodium chloride dilutions ranging at intervals of 0.5 per cent from distilled water to 5.0 per cent NaCl solution. A mean temperature of about 74 degrees F. was uniform for all tests. Seeds from which lots were selected were from a collection made in November of 1938. Tests were begun February 8, 1940. Low maximum germination in these tests may be ascribed to the waning vitality of the 1938 seeds used. Above 3.0 per cent NaCl no germinations were recorded. It is notable that germination in 0.5 per cent NaCl was slightly higher than that in the distilled water control. A previous test of 1938 seed in March, 1939, showed 95 per cent germination in tap water while responding 100 per cent in both 0.25 and 0.5 per cent NaCl solutions. A similar difference has been noted in work on other halophytes.

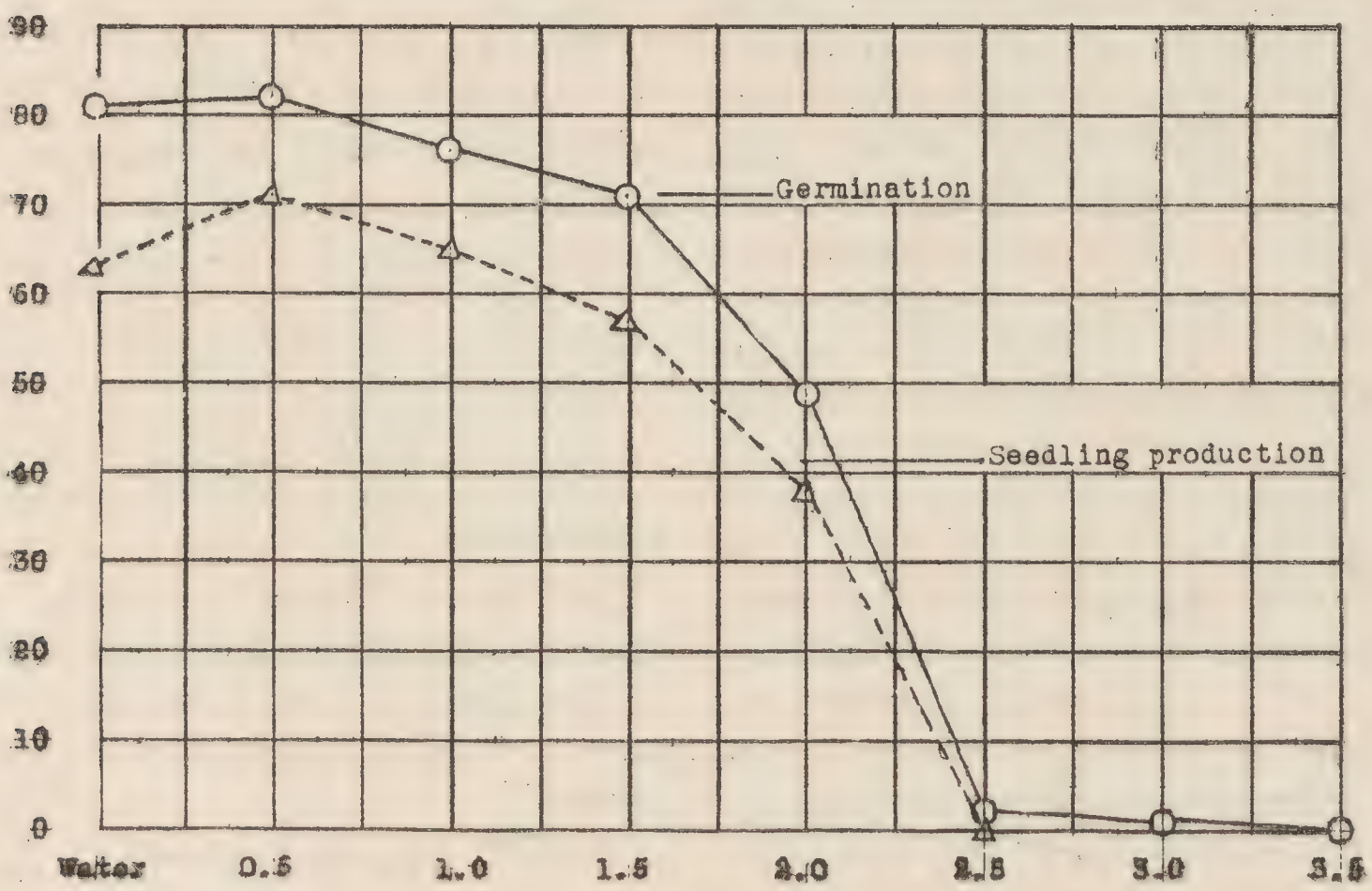
Germination was not markedly affected in either the March, 1939, or the February, 1940, experiments up to 1.5 per cent NaCl. Above this concentration, however, the decline was sharp and only few germinations were noted up to 3.0 per cent. Beyond this point no germinations were recorded. Seedling production in each lot was relatively proportional to their corresponding germinations, except no seedlings were produced in concentrations higher than 2.0 per cent. It is interesting to note that at 0.5 and 1.0 per cent concentrations a higher percentage of the total germinations resulted in healthy seedlings than was recorded for the distilled water control.

Early Root Development.

For purposes of this experiment, *Eurotia* seeds from the 1938 collection were planted in small paper pots in soil flats and later transferred to six-inch soil pots. One plant was placed in each pot and was watered each third day until the time of its removal. Plants were grown in the greenhouse at a mean temperature of 68 deg. Fahrenheit. Appearance of each shoot was recorded to avoid error in the later selection of plants of the same age.

Root length measurements were made at 3, 7, 14, 21, and at 42 days after plantings by selecting plants at random

Showing percentage germination and seedling production of seeds of Eurotia lanata in various concentrations of Sodium Chloride solution



Graph 3

throughout the block, washing them carefully, and laying them out on moist glass. Measurements were made by means of a centimeter rule which was quite usable for measuring early development, though inadequate for later and more extensive measurements. Attempts were made to measure projected root areas by means of a photometer, but, due to lack of essential equipment, correlation was low and the results consequently disregarded.

Three days after planting, 24 seedlings removed from the pots showed an average root elongation of 33 millimeters. In seven days an average root length of 50 millimeters had been attained with no lateral roots yet appearing. At fourteen days the average length of the tap-root had not greatly exceeded its length at seven days, but numerous lateral roots had developed which increased the total root area to 106 millimeters. At this time secondary growth of the shoot above the two seed leaves had also been initiated in most plants. After twenty-one days, 171 millimeters of root had been produced due largely to growth of the laterals. Secondary growth of the shoot was still taking place very slowly. In 42 days measurements showed an average total root production of 621 millimeters per plant. The taproots averaged about 8 inches in length, and numerous laterals and sub-laterals had greatly elongated.

Eurotia plants grown in water over sand in shell vials produced tap-roots ranging to 18 inches in length in less than 4 months. Meanwhile few laterals were produced.

Effects of Bracts and Pericarp on Germinability.

Seeds of *Eurotia* collected in November, 1939, were germinated the following March in different solutions in petri dishes and under otherwise similar conditions. The solutions were distilled water, seed-ball decoction, 1.0 per cent and 5.0 per cent prepared urea. The

seed-ball decoction used was prepared by soaking seeds of *Eurotia* with pericarps and bracts intact, in 5 times their weight of distilled water for 24 hours, and filtering off the resulting yellowish-green liquid. Urea solutions were prepared from a synthesized powder form. Temperatures were too warm for optimum germination but were equally applicable to all tests. Germinations were 96 per cent in water, 85.5 per cent in seed ball decoction, 60 per cent in 1.0 per cent urea and 0 in 5.0 per cent urea. The 10.5 per cent reduction in germination of the seeds in the seed ball solution below that of seeds in water was probably due to the effects of the decoction.

A soil test designed to measure the physical restraint placed upon the embryo by the presence of bracts indicated no significant difference in shoot production, although the appearance of the shoots was delayed briefly by the presence of the subtending bracts.

Other Investigations.

An experiment conducted in 1939 indicated no marked difference in productivity of seeds of *Eurotia* planted in native and in prepared soils.

Seeds of *Eurotia* were placed in shell vials containing water. Cotton plugs held them below the water's surface, and the air was excluded by a layer of olive oil. None of the seeds germinated.

Seeds of *Eurotia* planted one-half inch or deeper in soil fail to reach the surface under high soil temperatures.

Light is not a critical factor in the germination of *Eurotia.*

The hairy bracts subtending *Eurotia* seeds probably aid dispersal by clinging to the wool of sheep and by rendering the seed more buoyant to wind transport.

Viable seeds of *Eurotia* were not found in sheep droppings which produced several other species when planted in sterile soil. The seeds are undoubtedly digested by the animal since they are injested in considerable quantity.

Abstract

ORACLE BONES OF ANCIENT CHINA

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In the latter half of the nineteenth century, farmers in the northern section of Honan Province (China) discovered that after plowing or after a rain, bones of a very peculiar sort came to the surface. Some of these bones had mystifying markings in the form of geometrical designs or figures and small pictures.

For some decades these bones were thought to be "Dragon Bones" and many of them found their way to druggists' mortars where they were ground into powder for medicinal purposes. But about 1899 some of these bones came into the hands of Chinese antiquarians skilled in the most ancient forms of Chinese writing who recognized that the strange markings and designs on the bones must be a still older form of writing.

With this event an entirely new epoch in our understanding of the history of man in the Far East began. These fragments of bone with their inscriptions were in fact part of the Royal Archives of the Shang Dynasty (1766-1122 B. C.) and reveal subject matter of the most valuable historical significance.

This adventure in scholarship has been as thrilling and in many ways as notable an achievement as the decipherment of the Egyptian Hieroglyphics, upon the discovery of the Rosetta Stone by an officer of Napoleon's army about 1799.

PUTTING RESEARCH TO WORK

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Research provides the necessary information through which a more effective use can be made of natural and human resources upon which economic development depends. Through research new or improved techniques of management, production, and distribution are developed. Its value, however, is dependent upon the degree to which people are willing to adopt its recommendations. To achieve this goal the facts must be made available to all who can use them. The dissemination of this information is as vital as the research itself.

Practical Demonstrations Vital to Research.

The average person is more interested in results than in the processes of research. Outside a few highly technical fields the value of and need for research are not fully recognized. Consequently, practical demonstrations to show what can be achieved under actual working conditions by the adoption of new principles and techniques discovered in the laboratory or experiment station are extremely effective.

Agriculture and forestry are especially adapted ot this procedure. Soil erosion is a major national problem. Through research and careful experimentation, the causes have been determined. The problem is how to get farmers to adopt the remedial measures that have been devised. Erosion resulting from unsatisfactory land-use practices can be actually observed and measured on specially prepared plots side by side with others that show what takes place when improved methods are employed. Actual conditions of soil, slope, drainage, cover, and run-off can be simulated on these demonstration plots with a high degree of accuracy.

Demonstration can be carried one step further. The practical benefits resulting from the adoption of scientific land-use practices adapted to particular local conditions are being very effectively demonstrated on going farms. Under expert guidance, the operator puts into practice specific cultivation techniques and cropping systems which research has indicated as likely to produce beneficial results. Here is the practical application of research that farmers can appreciate. When, for example, an unusually fine stand of wheat is found adjacent to a mediocre crop, or when soil wash is negligible on one field and rampant on adjoining areas, people naturally want to know the cause and what can be done to remedy the situation. Such questions lead to discussions of improved farm practices, scientific fertilization adapted to soil and crop conditions, desirable crop sequences, etc. Discussion backed by demonstrations frequently but by no means always achieve the desired end. Other farmers adopt similar measures on their land, usually with beneficial results. Research is put to work.

Similar procedures are followed in connection with forestry. Trained foresters are constantly engaged in research concerned with the growing and management of trees. Experimentation is carried on in nurseries and in selected forest units. On the basis of this work, specific techniques are evolved for dealing with different aspects of the problem. The relative merits of one method as compared with another can be readily determined when they are applied to actual forest situations. The general application of the results of these scientific studies in silviculture, reforestation, etc., tends to be limited to the national forests and a few of the

private holdings where scientific forest management is being put into effect.

For similar purposes the engineering experiment stations translate test tubes into pilot plants to determine and then demonstrate the commercial feasibility of a particular technique. Even when these have proved their worth, economic and other factors may operate to prevent their practical application.

Research in Operation.

Innumerable examples can be found to illustrate how research is actually put to work, but for the purpose of this paper, the choice is restricted to a few that apply particularly to the Northwest.

Soil Conservation.

Soil erosion is the principal reason for impoverished land. The causes contributing ot soil erosion are known. Through research, means of preventing and checking it have been devised that that stood up under severe tests. Even though a farmer studies the literature and demonstrations of the Soil Conservation Service, he may be unable to apply them on his own farm without additional help and expert guidance. Soil and land-use capability surveys of his land may give him the help he needs to do a better job with perhaps some advice periodically from the land-use specialists and county agent.

Effective soil conservation necessitates cooperative action on the part of groups of farmers since malpractices on one unit may nullify corrective measures taken on adjoining farms. To meet this contingency the organization of Soil Conservation Districts has been legalized. Such districts are organized only after a majority vote of all land owners in the area involved has been obtained. Each District operates as an independent unit. Working in cooperation with experts of the U. S. Soil Conservation Service, each District, among other functions, carries on local erosion control research, demonstration projects, and formulates land-use regulations adapted to local conditions. To insure democratic control these regulations cannot be enforced until they have been approved by a two-thirds majority of all land owners in the District. While these organizations carry on some local research, their major function is to put into operation scientific land-use practices that have been developed through intensive research. In so doing they materially foster the agricultural stability of the region.

Land Use Planning.

The present investigations connected with the Columbia Basin Project provide an excellent example of the use to which research can be put in planning for the development of a new area.

One of the major tasks is to determine in advance of settlement the type of farm economy which is most likely to succeed in the various subdivisions which have been set up.

In order to profit by actual experience in similar types of areas elsewhere, careful surveys have been made of irrigated areas in, for example, the Kittitas Division of the Yakima Project, Washington, where a definite land-use economy has been in operation for a number of years under conditions not unlike those of parts of the Columbia Basin Project. Trained investigators analyzed land-use practices in relation to the environmental set-up, both physical and economic. By actual case studies, they determined the life history of a number of farm units. From these they were able to discover the optimum uses of the land under particular soil, slope, and drainage conditions. The principal problems confronting the operators and the measures devised to meet them have been carefully analyzed. The water requirements of different soil and crop types have been checked. Living conditions have been studied and particular attention has been given to a study of social and economic relationships. With a complete picture of the situation, the in-

vestigators know what has succeeded in the Kittitas District. They know what has failed and why. On the basis of this information, they expect to be able to draw up land-use plans that will have a reasonable chance of success in those parts of the Columbia Basin Project where a similar environmental complex obtains.

Selective Logging.

In view of the importance of forests and forest products in the economy of the Pacific Northwest, research has been directed toward the promotion of a more effective forest management and utilization of forest products.

Forests add materially to the scenic attractiveness of the Northwest—an attractiveness that is destroyed by indiscriminate logging operations. Preservation of the forest cover is also an important factor in maintaining tourist interest at its present level. An interesting example of what can be done through cooperative arrangements, to apply the principles of scientific management to solve a practical problem, occurred recently at Baker Lake, Whatcom County, Washington. Lumbering operations threatened the ruin of this scenic spot within easy reach of Seattle residents. Part of the timber on the slopes around the lake is owned by a lumber company while the remainder forms a part of the Mt. Baker National Forest. To have clear cut the privately owned timber would have seriously impaired, if not destroyed, the attractiveness of the whole area. To avoid this calamity a cooperative agreement was made by the company and the United States Forest Service whereby the area would be selectively logged under the general supervision of Forest Service technicians. To compensate for the commercial timber left uncut on its land, the company was allocated similarly selected trees of equal value in the adjoining national forest. Today, the lake and vicinity retains all its former charm, valuable commercial timber has been removed, and the forest has been left in excellent growing condition.

In the Ponderosa Pine region, much research and experimentation have been carried on to determine the optimum permissible cut in a sustained yield program. Rates of growth have been computed under various forms of management. Various management techniques have been tried out in the experimental forest at Pringle Falls, Oregon, to determine the most desirable stand that should be left after logging to insure optimum growth and natural regeneration. These data have been checked for a number of localities and under various conditions. By careful surveys it has been proved conclusively that to provide adequately for natural regeneration, as well as for continuous productivity, reduced cutting is necessary. The present rate of depletion exceeds growth by a wide margin. Consequently, if communities such as Bend, Oregon, are to be stabilized, some balance between cut and growth must be established.

As a result of these investigations, two large lumber companies in the vicinity of Bend have entered into precutting agreements with the United States Forest Service. They have agreed to leave 50 per cent of the stand on their holdings uncut. In return they will be permitted to log timber of equal value in the adjacent national forest. The selection of trees to be cut in each case will be made by the Forest Service. By this procedure clear cutting will be avoided, tree growth will be accelerated, the creation of additional unproductive areas will be checked, and the forest lands will be kept continuously productive. Other logging companies will doubtless follow this example provided it does not entail too great a financial sacrifice, for without continuous supplies of accessible lumber the mills must eventually close.

Sustained Yield Management in Forestry.

Much thought and careful study have been given to the question of how sustained yield units can be organized around specific centers in which the lumber industry is the principal economic base. This practical application of forest management research is complicated by such factors as the "complex and chaotic pattern of ownership," and the development of sawmill capacity far in excess of what the tributary area can continue to supply continuously. Could the industry be more or less uniformly organized on a sustained yield basis, the future of scores of communities would be assured.

Although the problem has been by no means solved, considerable effort has been expended to determine, for example, the bases upon which sustained yield management can function successfully, the various factors that should be given consideration in setting up sustained yield units, and the conditions which, at the present time, prevent the general application of this principle.

Where large holdings are concerned, as in the case of the national forests and a few private owners, the problem of establishing satisfactory units is less complicated. A case in point is the Willard contract with the United States Forest Service to log 40,000 acres of mature timber in the Little White Salmon watershed of the Columbia National Forest on a sustained yield basis. The Broughton Mill was confronted with permanent shut-down owing to the exhaustion of its holdings and the Willard community was faced with the loss of its main means of support. The contract establishes a unit containing 180,000,000 board feet, which is adequate to permit the mill to continue operation at its present rate, 1,750,000 board feet per month, in perpetuity, provided the procedures incorporated in the terms of the contract are followed.

New Uses for Wood.

Research is becoming increasingly important as a guidepost in every branch of the lumber industry. The nerve center for the study of wood chemistry and the industrial uses of wood is the United States Forest Products Laboratory, Madison, Wisconsin. Smaller, but often more specialized laboratories, are maintained by private industry in a number of centers. Their primary objectives have been to discover ways and means of utilizing the various types of wood more completely and effectively and to develop new and improved products. Research has directed every new development in connection with such products as plywood, pulp and paper, rayon, plastics, lignin, and dyes. Nevertheless, much additional work is necessary before the waste of potentially valuable by-products, such as lignin, is eliminated.

The discovery of water resistant synthetic resin adhesives, a product of the laboratory, is having far reaching effects upon the lumber industry and the expansion of economic opportunity. They have been largely responsible for the spectacular growth of the veneer and plywood industries. They make possible the more economical use of lumber, the fabrication of forms not readily produced from the log, and a more effective use of veneer in high grade cabinet work. Laminated woods are finding ever widening structural uses, owing to their superior strength compared with natural lumber. The size of the log need no longer be the prime factor in determining the dimensions of finished lumber.

Similarly, the chemist has developed improved preservatives and the engineer the means of impregnating lumber with these materials. Their use lengthens the life of wood under every kind of condition to which it is exposed.

Cellulose, the object of much productive research, can be adapted to pro-

duce a wide variety of industrial products for which there is a tremendous market. Wood is the principal source of supply since more than half its substance is composed of this vital material. Chemical research made cellulose available and is responsible for discovering the ways in which it can be utilized.

Best known of its many uses are the pulp and paper industries which have contributed so much to the economic development of the Northwest. The refinements which have occurred in production techniques, for example, the sulphite and sulphate processes, have been brought about through continuing research. Today, a major task is to discover ways of securing more economical production, higher yields, and better quality pulp not only from the timber now being used, but from species which, so far, have appeared to be unsuited for pulping purposes.

Chemically modified cellulose, viscose solution, can be spun into rayon, the most important synthetic fiber. The production of this material in the United States has increased from 300.000 pounds in 1911 to about 300,000,000 pounds in 1937. Consumption is now five times that of silk and about equal to that of wool.

By a modification of the viscose and acetate processes, a wide variety of plastics which have a multitude of industrial uses are being produced.

Because research in wood chemistry frequently has resulted in dollar and cents gains to the industry, terms readily appreciated by the lumberman, research of this type is beginning to be put to work in an increasing degree.

Conservation of Halibut.

The rehabilitation of the halibut industry is a fine illustration of what can be achieved through scientific research and the intelligent application of its findings.

Halibut have long been fished in a relatively narrow zone off the shores of Oregon, Washington, and British Columbia. For years little or no thought was given to conservation. By 1924, however, it had become evident that something was wrong. Once productive areas appeared to be fished out. Boats were forced to go farther afield to maintain their catches. Returns per unit of gear had diminished sharply. To many the industry appeared to be doomed. To the scientist it was obviously a case of serious overfishing that could be remedied only through drastic regulation.

Before remedial measures could be devised, three things were essential: complete data on the life history of the halibut, international cooperation in any action that might be taken, and cooperation of the people engaged in the industry.

The International Halibut Fisheries Commission was set up in 1924. By 1930 it had secured the data it needed and had formulated the conditions under which rehabilitation was feasible. By an intensive education program supported by scientific data, fishermen and others interested in the industry were convinced that stringent regulation was the only way out. This was vital because the Commission had no legal power to enforce its regulations. By closing one area completely, by restricting the catch elsewhere, by establishing a closed winter season, and by regulating the type of gear used, the halibut population is re-establishing itself. Careful records are kept to inform the Commission as to fishing conditions and to provide the data necessary for continued effective regulation. The close cooperation between fishermen and the Commission has prevented serious disagreements. As a result of these measures, the halibut catch has been stabilized at 48,000,000 pounds a year and the industry is now operating on a sustained yield basis. An interesting outgrowth of this work is the appointment of a similar commission to study the sock-eye salmon industry.

Industrial Development.

In the Pacific Northwest manufacturing has been restricted largely to the lumber and food processing industries with a resulting unbalanced economy. Now with the availability of large blocks of low cost Columbia River power, much thought is being given to the possibility of industrial expansion and diversification. It is essential that any development along these lines should be preceded by intensive research. It is particularly important to discover which industries would have a reasonable chance of success, the most desirable plant locations, and the readjustments that will be necessary to promote profitable operation. Failure to obtain these data may result in costly mistakes.

The various mining and engineering experiment stations have been carrying on much intensive study to determine ways and means of profitably utilizing the varied, but usually low grade mineral resources of the region. They have been developing special mining techniques, smelting processes, specialized equipment, economic methods for removing impurities and concentrating ores in order to make utilization practicable in competition with outside areas more fortunately situated. In some cases pilot plants have been constructed to determine the economic feasibility of laboratory processes. Electrometallurgical and Electrochemical, the so-called "heavy power using" industries, are receiving special attention. Much significant exploration work has been done in regard to the concentration of low-grade Washington magnesite ores, the production of electrolytic manganese, aluminum, and copper metal, sodium chromate and dichromate, calcium carbide, and iron and steel.

Closely related studies with more emphasis upon the economic aspects have been and are being made by the Bonneville Power Administration. By combining the findings of many diverse agencies and disseminating the information among those in a position to take action, tangible results are in evidence. Two large aluminum smelters using Bonneville power are now in operation. Numerous industrialists are giving Bonneville feasibility studies serious consideration. The present National Defense Program is likely to result in a fuller use of the available industrial research and to stimulate further integrated studies.

Research Reporting.

The Washington State Planning Council is actively engaged in stimulating industrial research in order to promote the industrial development of the state and the use of Washington raw materials. Several important projects are now under way at Washington State College through which new metallurgical industries will be made possible.

Effective reporting of research is vital. This should take two principal forms—technical and non-technical. The former is essential to the specialist desirous of keeping up with new developments in his specific field or to give direction to new research. The latter should be designed to meet the needs of the general reader who wishes to be adequately informed, those who would like to apply new ideas in their daily work, and the men who shape the economic and legislative policies of the region. Both types are necessary for an adequate dissemination of information.

Professional Journals.

Much valuable research data are published in professional journals or special bulletins. They reach a limited though potent audience. Usually they are couched in technical terminology of interest primarily to the specialist. They stimulate new research and direct the experimentation which often leads to valuable practical results on the farms and in the factories.

Non-Technical Reporting.

The layman is interested in results.

Usually his technical background is limited. He prefers brief non-technical explanations and directions presented in interesting, stimulating fashion. The length and manner in which many reports are written discourage all but the most persistent seeker after truth. Much valuable information often goes unused because of the uninviting format in which it is presented.

During 1939 more than sixty technicians and consultants collaborated in a regional study under the direction of the Pacific Northwest Regional Planning Commission. This culminated in a lengthy report, "Migration and the Development of Economic Opportunity in the Pacific Northwest." To date this is only available in a limited mimeographed edition. To remedy this situation and to reach a wider reading public, this report has been condensed and rewritten in a non-technical interesting style under the title, "Men and Resources." It is hoped that this concise document, sponsored by the Northwest Regional Council, will find wide use not only among the general public but also in schools.

Increasing attention is being given to this problem by both government and private agencies. The United States Department of Agriculture is more and more adapting its publications to the non-technical reader. Farmers' bulletins, soil conservation studies, and forest reports, for example, are appearing in much more attractive forms, designed to stimulate reader interest and inform the general public, whose understanding and appreciation of research is essential to any continued and substantial support. Private industry also has adopted this practice to keep the buying public informed of improvements in their techniques and products that have resulted from the labors of their research chemists and engineers. Increased sales are evidence of the efficacy of this method of arousing public interest.

Short, well written essays bringing together the latest research on significant problems provide another means of stimulating interest in vital issues. They can be directed at any level. "Pacific Northwest Problems and Materials," another publication of the Northwest Regional Council, includes a series of such essays through which, it is hoped, high school students can be made aware of what is being done to solve important regional problems through the processes of research.

Data relating to a single topic is often contained in numerous sources not always readily accessible. Unless this information can be brought together, digested, and made available in reasonably small compass, it is rarely effectively used. This can be done for any educational level. Much research has been devoted to the migration problem in the Northwest. Numerous books and articles have been written recording the results. Here is a problem of vital concern to young and old throughout the Northwest. This modern saga is dramatically portrayed by word, picture, and color in "Caravans to the Northwest." This brings together the essential facts for a broad understanding of the problem and presents them in a way that should stimulate interest. The migrants are real persons, the problems they create are real, and by this method research has been made meaningful.

Research is essential to human progress and without it rational development is impossible. But, to realize its full value, it must be translated into action.

Abstract
THE PHYSICAL-CHEMICAL PROPERTIES OF ALCOHOL-GASOLINE BLENDS

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It has been proposed to utilize surplus farm crops by converting them to anhydrous ethyl alcohol to be used as a motor fuel in the form of blends with gasoline. In considering the technical aspects of such a program it is first desirable to investigate the physical-chemical properties of the blends to determine whether or not they can be used in present day gasoline engines and what if any changes must be made in engine adjustments to permit use of such fuels in an economical manner.

Anhydrous ethanol and gasoline are miscible in all proportions and the physical-chemical properties of such blends are not a linear function of composition. Within the range of 0 to 25 per cent of alcohol by volume, the blends differ from the gasoline base to about the same degree that commercial gasolines vary. It is thus indicated that such blends may be used interchangeably with gasoline in present day engines.

Ethanol has a very high antiknock hygroscopic, contrary to general opinion, and alcohol-gasoline blends show no tendency to absorb water under conditions easily maintained in commercial distribution and use of motor fuels.

Ethanol hasa very high antiknock value and in blends with gasoline it shows an apparent octane blending value of 100 to 200 octane. Blended with gasolines of 55 to 65 octane rating, its average blending value is about 150.

Power and economy tests in the laboratory show that with air-fuel ratios between the points of maximum economy and maximum power, blends containing 10 per cent of ethanol yield greater power and lower specific fuel consumption than does gasoline. Only with higher air-fuel ratios than that for maximum economy is the blend inferior to gasoline as regards power developed or fuel economy.

Since most commercial engines are operated with air-fuel ratios lower than that for maximum economy, it is to be expected that blends should yield greater power output and lower fuel consumption than does gasoline, and this is the result observed in carefully controlled road tests.

Thus both theoretical considerations and actual bench and road tests show that blends containing up to about 25 per cent of anhydrous ethyl alcohol can be used interchangeably with gasoline of equal antiknock rating, and when used in this way the blended fuel is in most respects the better fuel.

Abstract
GLACIATION IN THE METHOW VALLEY, WASHINGTON*

JULIAN D. BARKSDALE
University of Washington

During a glacial maximum, ice from the Methow drainage joined with ice of the Okanogan lobe to form an almost continuous blanket covering all but the highest peaks of the northern Okanogan Mountains and the eastern Cascade Range. Much of the Methow ice was contributed southward through the present north-flowing middle and west forks of the Pasayten River. A true valley glacier occupied the Methow during a late stage of the glaciation, building moraines as far south as Libby Creek, but it apparently did not join the Okanogan ice at the mouth of the Methow.

*This paper was published in full in the Journal of Geology, October-November 1941, Vol. 49, pages 721-737.

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Life Memberships and Research Funds of the Northwest Scientific Association

It is probably not known to many members of the Northwest Scientific Association that, according to article 3 of the revised constitution of the Association, provision is made for five types of membership in the organization. Article 3 reads as follows:

Membership:

Membership in this organization shall be divided into the following classes:

(1) Member. Anyone interested in the purpose of the society may become a member upon annual payment of one dollar.

(2) Institutional Member. (a) State Universities, colleges and similar educational institutions. Annual dues, $25.00. (b) Normal schools, other educational institutions and professional organizations. Annual dues, $10.00.

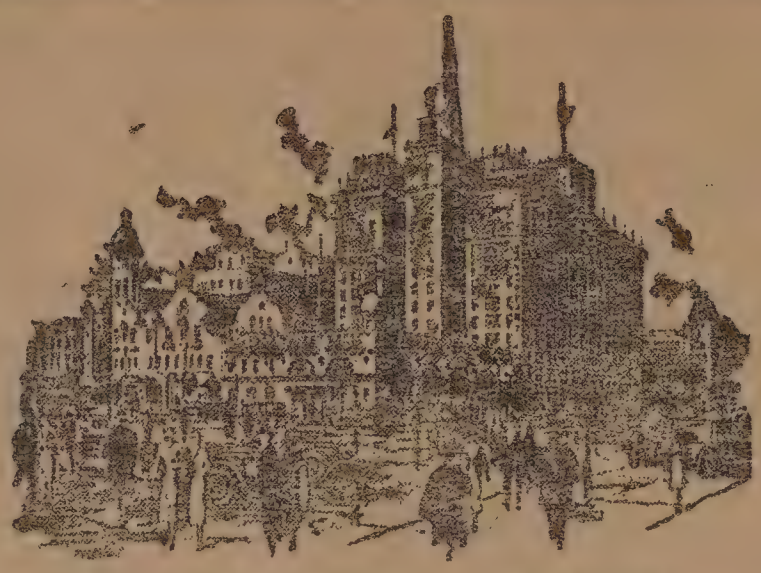
(3) Life Member. Life membership may be obtained on the cash payment of $25.00, or by paying $6.00 per year for five years.

(4) Supporting Member. Supporting membership may be obtained by a minimum payment of $100.00.

(5) Patron. Persons contributing $1000.00 or more to the Association shall be known as patrons.

Institutional members of the Association are the University of Idaho, State College of Washington, Whitworth College, Eastern Washington College of Education, Central Washington College of Education, and Western Washington College of Education. The income from these institution members is $90.00 per year which helps materially in covering the deficit on Northwest Science. In fact, the publication could not be maintained in its present form without the income from advertisements and institutional memberships. The ordinary $1.00 membership fee is not enough to cover the other expenses of the organization and the entire expense of the publication of Northwest Science. So far there are no supporting memberships or patrons of Northwest Science, but it is hoped that philanthropically minded individuals interested in the advancement of science can be induced to join the organization as patrons or supporting members. There are now several life members of Northwest Science. The expense of life membership is a cash payment of $25.00 and it is believed that many members and friends of Northwest Scientific Association should be interested in becoming life members. The annual $1.00 membership fee represents interest at the rate of 4% on $25.00, and since it is difficult in these times to net that much income, an individual would find a life membership a good investment in addition to knowing that his money would be used to advance scientific research in the Northwest. It is hoped that many members will welcome this opportunity and will decide to become life members of the Northwest Scientific Association.

The Association also administers the Howard Flint Memorial Fund, which now totals well over $1000.00, the income from which is allocated for research on projects in the Northwest. The sum of $50.00 per year is received from the headquarters of the A. A. A. S. and allocated for research in the Northwest. In addition, individual gifts of 50c to $1.00 and up are solicited for allocation of research activities in the Region.



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